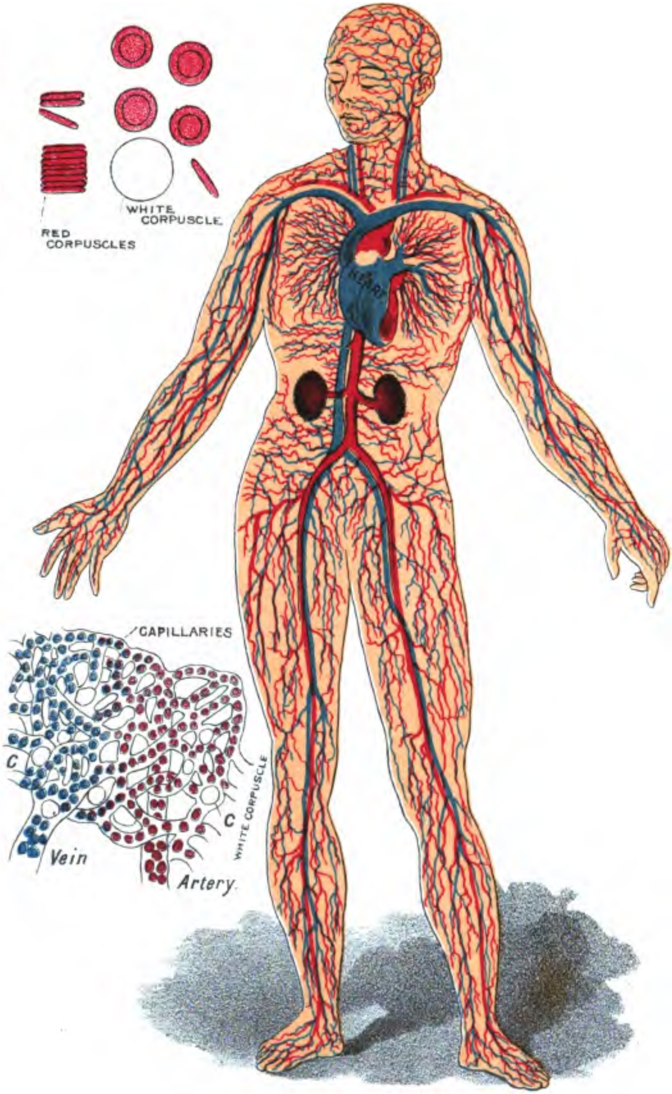
Second Book in Physiology and Hygiene

Kellogg



· PLATE I · THE CIRCULATION ·

SECOND BOOK

IN

PHYSIOLOGY AND HYGIENE

BY

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PREFACE.

In the preparation of this volume the aim of the author has been to present only such facts as are of practical value, and to arrange these facts in a natural and logical order.

Those portions of the work devoted to Anatomy have been made as untechnical as possible. The author sees no advantage in burdening the student with Greek and Latin names for which he has no practical use. In accordance with this view, anatomical names have been used very sparingly. The aim has been to teach *things* rather than *names;* and only such anatomical facts have been presented as are necessary to a proper understanding of the leading functions of the body.

From the vast store of facts comprised in the modern science of physiology, the author has endeavored to select only those which are essential to an understanding of the "reason why" in respect to the hygienic precepts inculcated in those portions of the work devoted to hygiene. Nevertheless, it is believed that the work will be found to contain a more complete statement of the established truths of modern physiology than any other work of its class, as an effort has been made to bring within the comprehension of the student a considerable number of important facts which have been usually omitted in school text-books upon this subject. This is particularly true as regards the functions of digestion and the physiology of the nervous system. It is believed that experienced teachers will find the manner in which these subjects are developed of great service in clearing away the difficulties which they ordinarily present to the average student.

In those chapters of the work which are devoted to Hygiene, the author has endeavored to include all essential facts relating to individual hygiene suitable for consideration in a work of this character, and the treatment of this subject will be found unusually full and complete. The author has studiously avoided dogmatic statements, endeavoring to give a clear and sufficient reason for each hygienic requirement stated.

Especial attention has been given to that branch of hygiene which relates to the abuse of alcohol, tobacco, and other narcotics and stimulants, and it is believed that no important scientific fact relating to this subject has been omitted; and a number of new, and it is believed valuable, facts are presented from the results of the author's original researches.

The attention of teachers is especially called to the numerous experiments described in the body of the work and in a separate section, which the author feels assured will assist very greatly not only in making clear to the mind of the student the subjects illustrated, but in so impressing them upon his mind as to greatly assist the memory. The earnest teacher will be able to supplement the experiments described by many others equally impressive and useful.

The author gratefully acknowledges large indebtedness to his friend Sir B. W. Richardson, M.D., F.R.S., of London, England, not only for his laborious researches, which have thrown so great a flood of light upon the question of the influence of alcohol upon the human body, but for his kind interest in this work and a careful revision and approval of the manuscript.

It has not been thought best to cumber the text with too many illustrations, as the author has prepared a number of colored charts which illustrate in a very complete manner the subjects of anatomy, physiology, and hygiene.

BATTLE CREEK, MICH., April, 1894. J. H. KELLOGG.

CONTENTS.

SECOND BOOK

IN

PHYSIOLOGY AND HYGIENE.

CHAPTER I.

PHYSIOLOGY, ANATOMY, HYGIENE.

1. **Physiology.** — The ancient philosophers taught their pupils in the open air, walking about through the fields and groves, and giving instruction concerning the various objects they met. This intimate study of nature was called by the old Greeks *physiology*, which literally means a discourse upon nature.

The word *physiology* is now used in a somewhat different sense. It is applied to the study of the properties, uses, and actions of the various parts of living things. Physiology deals with plants and lower animals, as well as with human beings; but our study of the subject will be chiefly confined to that department of physiology which relates to the human body.

2. **Anatomy.** — The body is made up of a great number of separate parts, some of which are wonderful in form, and marvellously intricate and delicate in structure. The study of the form and structure of

these various parts, and of their relation to each other, is called *anatomy*.

3. **Hygiene.** — To maintain the body in health, it is necessary that certain conditions should be supplied. Hygiene treats of these conditions, and of the rules which must be followed to preserve health and vigor.

One of the most important branches of the study of hygiene relates to the avoidance of substances by the habitual use of which the delicate structures of the body may be injured, and rendered incapable of executing in a perfect manner the important duties they are intended to perform. Among the most commonly used substances of this sort are alcoholic drinks, tobacco, and other so-called stimulants and *narcotics*. Of these substances, and their special harmful effects upon the various organs of the body, we shall learn in future lessons.

SUMMARY.

1. *Physiology relates to* the properties, uses, and actions of the various parts of the body.
2. *Anatomy considers* the form and structure of the body.
3. *Hygiene treats of* the conditions which are essential for the maintenance of health.

CHAPTER II.

CELLS, TISSUES, ORGANS.

4. **Cells.** — A drop of water from a stagnant pool, when placed under a powerful microscope, is seen to contain multitudes of living creatures, some animal and some vegetable. Among the numerous living forms is found a curious little creature, the *amœba*, which looks much like a small drop of jelly. It is certainly very unlike the creatures familiar to us as animals; nevertheless it is alive, and may be seen to move about at will. It has no limbs; but when it wishes to move, it puts out a foot made for the occasion. It has no mouth, yet it can eat. It spreads itself around any tiny morsel of food which may happen to come in its way. This curious living atom has many remarkable ways and properties which we have not space to study. It is sufficient for our present purpose to know that it is the simplest of all living creatures, the smallest of animals, and that it is called a *cell*. The living, active parts of all animals, and of vegetables also, are composed of cells.

If instead of a drop of pond-water we examine with the microscope a drop of blood, we shall find in it living jelly-drops, essentially like those found in the pond, but smaller. In the brain, the liver, the muscles, the bones,—in fact, in every part of the body,—the microscope shows cells which are in some respects similar to those of the pond and of the blood.

All cells are active workers; and each has its special work to do. The human body may be aptly compared to a community made up of multitudes of individuals. In most communities there are various classes of workers —carpenters, blacksmiths, jewellers, chemists, merchants, teachers, etc. In the body, likewise, there is a division of labor. Some cells build, others tear down. Some cells may be compared to artists, others do the work of scavengers. Some construct solid parts, others make the various fluids to be employed in the body or to be removed from it. Some act as sentinels, to give the body warning of danger; others defend it when attacked by the enemies of life or health. All labor together in the most perfect harmony when their work is not in any way interfered with.

5. **Growth.** — All living things grow. This is one of the characteristic differences between an animal or a plant and an inanimate object, as a rock. Masses of inanimate matter may be increased in size by the simple accumulation of material; but this is not growth in a physiological sense. A plant grows by taking into its leaves and roots air, water, and matter in solution, converting them into its own kind of substance. Animals grow in essentially the same way, by taking food into their bodies and converting it into their own structure.

6. **Organs.** — A tree has leaves, bark, roots, branches, etc., each of which has special properties and uses. So, also, an animal has distinct parts, as a mouth, stomach, head, legs, and feet, each of which performs some special service for the animal. Each part of an animal or a plant which has some special work to do is called an *organ.* All animals and vegetables possess organs, and are accordingly said to be *organized*, and to belong to

the *organic* world. A rock or a mountain possesses no organs, and hence belongs to the *inorganic* world.

7. **The Tissues.** — Each organ is composed of a few simple structures, called *anatomical elements* or *tissues.* The whole body is made up of these elements, which are variously combined and arranged to form the several organs, just as the wood, brick, stone, etc., of which a house is composed are combined in various ways in the formation of the various parts of a house. A large part of the work of the cells of the body consists in the development and repair of these tissues.

Fig. 1.—Yellow Fibrous Tissue.

Fig. 2.—White Fibrous Tissue.

8. **Fibrous Tissues.** —In all parts of the body there are found long, white, thread-like fibres, which are very tough and unyielding. This is the kind of tissue needed to bind the different parts of the body together, and to make cords and protective coverings, for which purposes it is used. This is known as *white fibrous tissue.*

Another form of fibrous tissue, somewhat similar to the preceding, but yellow in color, coarser, and capable of contracting after being stretched, very much like India-rubber, is known as *yellow elastic tissue.*

The yellow elastic and white fibrous tissues together form in all parts of the body a finely woven meshwork, called *connective tissue.* This marvellously strong, though delicate, structure is found in every organ of the body binding together the various tissues, forming sheaths, membranes, bands, pouches, coverings, and thus serving everywhere purposes of protection and support.

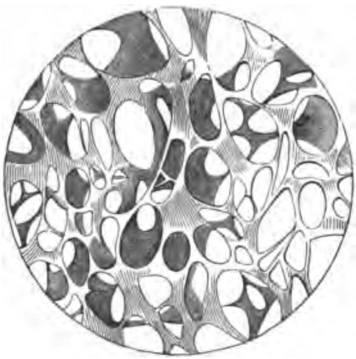


Fig. 3.—Connective Tissue.

9. **Adipose Tissue.**— In some parts of the body the meshes of the connective tissues are occupied by cells which are filled with fat. This is *adipose tissue.* This soft tissue forms cushions for delicate organs like the eye, rounds out the form, and serves several other very useful purposes.

10. **Osseous Tissue.** — A very dense tissue, the hardest in the body, forms the chief part of the bones, from which it is known as *osseous tissue.* This tissue is stronger than the toughest oak.

11. **Cartilage Tissue.** — Some organs require a tissue having something of the rigidity of the bones, and at the same time capable of yielding or bending a little under pressure. This requirement is met by the *carti-*

lage tissue. Most cartilages are connected with bones, which are themselves at first composed of this kind of tissue. In old age, many of the cartilages of the body become bony in character.

12. **Muscular Tissue.** — Those portions of the body which correspond to the lean meat of animals are made up of *muscular tissue.* Muscular tissue is composed of minute fibres, each of which is able to shorten and lengthen somewhat as an earthworm contracts and extends its body when in motion.

13. **Nervous Tissue.** — The brain and nerves are composed of cells and fibres possessed of properties the most remarkable to be found in living creatures. These cells and fibres constitute *nervous tissue.*

14. **Epithelium.** — Covering the whole surface of the body, and lining all its cavities, are found layers of curious cells. In one locality these cells assume one form, and in another a very different one. They are called *epithelial* cells, and the covering which they help to form is called *epithelium.*

15. **Tissue-builders.** — As we have learned, all of the various tissues are built and maintained by living cells. Life depends immediately upon the proper and continuous activity of these cells. Anything which impairs their vigor or hinders their activity, injures health and threatens life. Hence we should make a careful study of our bodies, and should endeavor to ascertain how best to maintain in health and vigor the vast army of little workers which carry on within them the various operations upon which life depends.

16. **Tissue-destroyers.** — There are numerous substances which, when taken into the body, exert a most damaging influence upon the delicate tissues of which

it is composed. Among the most harmful of these are alcohol and tobacco. Alcohol, in particular, occasions very great mischief. When brought into immediate contact with any of the tissues, it produces at first paralysis, then death. When taken in the form of alcoholic drinks, the injurious effects appear less quickly, but none the less surely. Every tissue of the body is injured. Many of the tissues are so changed that they lose their natural properties, and are hardly recognizable. These facts have been ascertained by numerous experiments upon animals, and by examinations made after death in cases of persons who had been addicted to the use of alcoholic drinks.

17. **Effects of Alcohol upon Connective Tissue.** —Alcohol is an irritant, and produces a harmful change in the connective tissue of various parts of the body, especially that of the liver and the brain. There is at first an increased growth of the connective tissue. Then the overgrown tissue contracts, and becomes hard and unyielding, like a scar. As a result, the delicate structures which the connective tissue should protect are compressed so as to injure them greatly, and finally they may be completely destroyed. This change is sometimes almost universal in the body of a drunkard.

18. **Effects of Alcohol upon the Tissue-builders.** —Still another charge which may be fairly brought against alcohol, is that it lessens the activity of the tissue-building cells, and when taken in a concentrated form, may paralyze them completely. This is one reason why a person who uses alcoholic drinks recovers less rapidly from an accident than does one who abstains from the use of this drug, a fact which has been noticed and remarked by many eminent surgeons.

19. **Effects of Tobacco upon Tissue-building Cells.**—Tobacco has a similar effect upon the cells which build and repair the tissues. This is the reason why the use of tobacco stunts the growth and prevents the proper development of a boy who begins its use at an early age. It is for this reason that all physicians agree that the use of tobacco by young persons is most pernicious in its effects.

Opium and other narcotic drugs affect the tissue-builders in essentially the same manner, and hence are dangerous enemies to health and life.

20. **Health and Disease.**—When all the cells and organs of the body are acting properly and harmoniously, an individual is said to be in a state of *health*. When for any cause an organ ceases to act, or acts in an unnatural or disorderly manner, the individual suffers discomfort, and is said to be in a state of ill-health, or *disease*. The causes of disease affect the body harmfully through their influence upon its living cells.

SUMMARY.

1. All living things are composed of *cells*, to which their activities are due.
2. Through the action of their cells, animals and plants *grow*.
3. Animals and plants have organs, and hence are *organized*. From this we have two classes of objects in nature, *organic* and *inorganic*.
4. The ultimate elements of which the body is composed are called *tissues*, of which there are six, *fibrous*, *adipose*, *osseous*, *cartilage*, *muscular*, *nervous*.
5. The tissues are built and repaired by cells.
6. Certain substances, particularly *alcohol*, *tobacco*, *opium*, and other *narcotics*, when taken into the body, paralyze the tissue-builders, and destroy the tissues.
7. The harmonious activity of all the bodily organs constitutes *health*. A state of disorder in the body is *disease*.

CHAPTER III.

NUTRITION.

21. **Wastes and Losses of the Body.** — Just as a steam-engine in doing its work gives off smoke and ashes, and loses steam and heat, so every movement of the body results in waste from the wearing out of the tissues and the using up of materials. Every movement of the limbs in walking or running, every motion of the hands or arms, the smallest movement of a finger, the beating of the heart, or even the winking of an eye, causes waste or loss of substance.

22. **Amount of Bodily Wastes.** — The amount of waste or loss depends chiefly upon the kind and amount of work performed, just as with a locomotive engine the amount of steam, smoke, and ashes lost depends upon the speed at which it runs and the load it has to draw. That the loss is considerable is seen in the fact that when deprived of food the body rapidly diminishes in weight, usually at the rate of several pounds daily.

In addition to the loss of tissue substance, the body sustains certain other losses, the most important of which are of *water* and *heat*. Water is lost chiefly in connection with the removal of waste substances. Besides that which is removed through the bowels and the kidneys, water is constantly passing off through the lungs and the skin, in the form of an invisible vapor. The moisture of the breath becomes visible when one

is breathing in the open air on a frosty morning; and when one exercises violently, or is exposed to extreme heat, the water thrown off by the skin becomes visible in the form of sensible perspiration, or sweat. The amount of water lost daily is three or four pints.

23. **Excretion.** — The removal of waste products from the body is called *excretion*, and is one of the most important of all the vital processes. The organs by which this work is accomplished are the lungs, liver, bowels, skin, and kidneys.

24. **Loss of Heat.** — The temperature of the body is constantly maintained, during life, at a little less than 100° Fahr. A thermometer held in the mouth for a few minutes indicates 98½° Fahr. The constant formation of heat within the body makes it necessary that heat should be continually given off, to prevent the temperature of the body from becoming too high. In cool or cold weather, heat is given off chiefly by the contact of the body with the surrounding air; in very hot weather, the body is cooled by the evaporation of moisture from its surface.

25. **Repair of Wastes and Losses.** — Nature has made provision for the prompt repair of wastes, so that under ordinary circumstances, in a state of perfect health, each loss is made good almost as soon as it occurs. The process of repairing wastes is known as assimilation. Each tissue possesses the power to take from the blood the elements necessary to replace those which it has lost through the wear and tear of bodily work. In infancy and childhood, assimilation overbalances waste, so that the individual increases in size. In grown persons the two processes are evenly balanced, and the body neither gains nor loses. In old age, waste overbalances assimi-

lation, and so the body gradually grows weaker and smaller, until death occurs from disease or a general wearing out of the system. The reverse of assimilation, or the breaking down of the tissues, is known as *disassimilation* or *disintegration.*

26. **Glands.**—Much of the work connected with the repair of the tissues and the removal of waste matters is performed by a very remarkable class of organs, called *glands.* A gland is an organ which makes from the blood a fluid peculiar to itself and very unlike the blood. If the fluid thus formed is intended for use in the body, it is called a *secretion;* if it is intended to be removed from the body, it is called an *excretion.* The saliva is a secretion; the perspiration, or sweat, an excretion.

The structure of glands is very interesting. The simplest gland is merely a little pouch in the skin or mucous membrane, lined with cells capable of making some special fluid. In more complicated glandular structures we find two or more pouches with a common opening. In large glands we have a large number of these pockets or pouches gathered together in a single mass, and pouring the product of their work into a common canal, called a *duct.*

27. **The Materials Needed for Repair of Wastes and Losses.** — The constant loss of matter from the body makes it necessary that a regular supply of new material should be received. The system requires three classes of substances to supply all its needs: 1. *Organized material*, in the form of vegetable or animal substances; 2. *Water*, a liquid; 3. *Oxygen*, a gas. In future chapters we shall learn how these necessary materials are introduced into the body, and shall study the different processes by which the body makes use of them.

28. **The Hygiene of Nutrition.**—In order that the body shall be maintained in health, it is necessary that a proper balance between waste and repair should be maintained. The necessary materials to make good the losses of the body must be supplied in proper quantity. The waste and poisonous substances formed within the body must be promptly removed, and substances of a poisonous character must be carefully excluded.

29. **Alcohol, Tobacco, and Opium.**—Among the most dangerous of all enemies to health and life are all kinds of alcoholic drinks, tobacco, and the different preparations of opium. When any of these poisons are taken into the body, they come in contact with the delicate cells which do the various kinds of work that are carried on in the body. All stimulants and narcotics injure these cells, interfere with their work, and thus do great mischief, often inflicting irreparable injury.

30. **The Effects of Alcohol and Tobacco upon Nutrition.**—Although we are not yet prepared to enter fully upon the study of the effects of these substances upon the body, it will be proper for us to notice briefly the harmful effects of some of them upon the general nutritive processes of the body.

Numerous experiments, made by eminent scientists at different times and in various countries, show conclusively that when any considerable amount of alcohol is taken into the body, almost the entire amount reappears in the excretions without having undergone any change like that which takes place in food. That is, alcohol reappears in the breath and other excretions as alcohol, or in the form of some substance so nearly like alcohol that it is easily recognized as being derived from it. A

very small amount of alcohol disappears in the body, but it has never been proved that any useful purpose is served by it. Alcohol not only does not make good the wastes of the body, but is a clog and hinderance to the delicate vital organs; for these organs are not only injured and weakened by it, but must devote to the work of removing the alcohol, energy which should be expended in removing waste substances.

A proof that alcohol injures the body in this way may be seen in the bloated appearance of a beer-drinker. His system is filled with impurities which should have been carried out of the body, but which have been retained because the organs of excretion have been employed in removing the alcohol and other impurities contained in beer. His blood is impure. He is, on this account, an easy prey to disease, and if he happens to suffer an accident, he is more liable to die than if he abstained from the use of alcoholic drinks.

But alcohol disturbs the processes of nutrition in other ways. It hinders assimilation, and destroys that nice balance between waste and repair upon which the health and symmetry of the body depend. This is often very noticeable in some portions of the face, particularly in the nose, which under the influence of alcohol, becomes red and inflamed in appearance, and often grows to be too large for the rest of the face. This condition is so characteristic of intemperance that such a nose is sometimes called a "rum blossom."

31. **Effects of Tobacco and Opium upon Nutrition.** — Tobacco and opium, as well as alcohol, disturb the processes of nutrition, although the effects are not precisely the same. These poisons, when taken into the body, must be removed. They cannot possibly serve any

useful purpose. They paralyze the tissue-builders, and hence their influence is most pernicious. The delicate organs by which the important processes of life are carried on are hindered in their work, being required to expend much effort in removing from the body the noxious intruders. The breath, and all other excretions of a tobacco-user, are tainted with the poison, showing that his body is saturated with it.

Tobacco, opium, alcohol, and all other poisonous substances, endanger health when taken into the body, by lessening the activity of the special cells which have for their duty the defence of the system against those most powerful of all the foes of human life and health, microscopic germs. These unseen agencies of disease and death are constantly about us. They float in the air as fine dust; they abound in water not obtained from the purest sources; and they are constantly present in various articles of food. Germs would quickly destroy our lives were it not for the fact that the body is supplied with a special class of cells, found chiefly in the lungs, the intestines, and the blood, which are capable of destroying germs, and thus defending the body against them. Tobacco, opium, alcohol, and other poisons paralyze these germ-destroying cells, and thus render the body defenceless against the attacks of disease germs.

We may learn many useful lessons in hygiene by the study of the lower animals. These creatures, so much inferior to human beings in intellect, are, in their habits of life, led chiefly by instinct. Their instincts being less perverted than are those of human beings, their natural appetites are more reliable guides than are ours. This is not because man was made inferior to lower animals

in this respect, but because by long yielding to unnatural appetites, and following harmful customs, his natural instincts have become perverted.

An instructive illustration of this principle is found in the fact that no lower animal, in a natural state, indulges in the use of substances which correspond in effects to the narcotics and stimulants so extensively used by human beings. This is not because lower animals are not affected by these drugs in the same way as are human beings, for it is well known by physiologists that, with a few rare exceptions, the effects of narcotics and stimulants on man and lower animals are essentially identical. A goat was once made drunk by some mischievous sailors, but afterwards ran away whenever approached by those who had once imposed upon him. It would be well if human beings always showed an equal amount of wisdom.

SUMMARY.

1. All *vital work* is accompanied by *waste.*
2. Bodily wastes consist in loss of tissue substance, water, and heat.
3. The removal of wastes is called *excretion.*
4. Tissue-building is called *assimilation;* tissue waste, *disassimilation* or *disintegration.*
5. Needed for nutrition—food, water, and air.
6. Needed for health—regular and sufficient supply of food, water, and air, and the prompt removal of wastes.
7. The most serious disturbers of nutrition are *stimulants* and *narcotics—alcohol, tobacco, opium.*
8. Alcohol clogs the tissues, hinders assimilation, and disturbs the balance of the nutritive functions.
9. Tobacco and opium clog the tissues and paralyze the tissue-builders.
10. No lower animal naturally uses narcotics or stimulants.

CHAPTER IV.

FOODS.

32. **What are Foods?**—In the preceding chapter we have learned that the body is constantly sustaining losses in consequence of the vital work performed by its various organs. Foods are substances which, when introduced into the body, make good its natural wastes and losses, and furnish proper material for the repair of its tissues, or for carrying on its vital processes. As we have already learned, these requirements are met by organized matter, water, and oxygen, or what may be termed solid, liquid, and gaseous foods. Of these, the first only is commonly known as food. Liquid foods are called drinks, all of which have water for their essential element. In this chapter our attention will be confined to the consideration of organized foods.

A *poison* is the opposite of a food. It not only does not repair wastes and losses, but interferes with the vital processes, disturbing them in such a way as to occasion sickness and death.

33. **Animal and Vegetable Foods.**—Man employs both animal and vegetable substances as foods. Some nations, particularly the English people and Americans, use a large proportion of flesh, and some barbarous tribes live almost wholly upon the flesh of animals; but the larger portion of the human race live chiefly upon vegetable foods. Many millions of human beings in

India and other parts of Asia never taste flesh, considering it a sin to do so.

34. **Plants the only Food-producers.**—Plants alone possess the power to construct living substance out of the elements of the earth and the air. Animals are able to subsist upon organized substances only, so that a lion, in dining upon an antelope, is only eating at second hand the grass and herbs which the latter has eaten; and a man, in eating roast beef, is taking at second hand the corn upon which the ox was fed.

35. **Food Elements.**—When a chemist examines a loaf of bread or a piece of meat, he finds it to be made up of various substances quite unlike each other, each possessing peculiar properties, and destined for different uses in the body when taken as food, called food elements.

36. **Classification of Food Elements.**—The various substances found in foods may be included in six classes: 1. *Starch;* 2. *Sugars;* 3. *Albumen* (all albuminous substances); 4. *Fats;* 5. *Salts;* 6. *Indigestible Elements.*

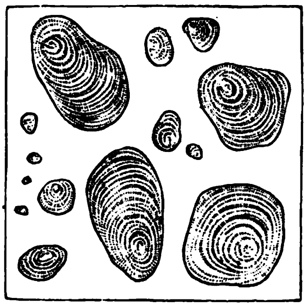


Fig. 4.—Potato Starch.

37. **Starch.**—This element is found only in vegetable foods. In a raw state, starch is found in small particles or granules, each enclosed in a woody envelope. Starch is the most abundant of all the food elements. (See Experiments 1 and 2, page 271.)

38. **Sugar.**—Sugar is very unlike starch in its general properties, although closely related to it. In the mysterious chemistry of plant life, the insoluble, tasteless

starch is converted into this sweet and extremely soluble substance. Several different kinds of sugar occur in nature, the most important of which are *cane*-sugar, *grape*-sugar, and *milk*-sugar.

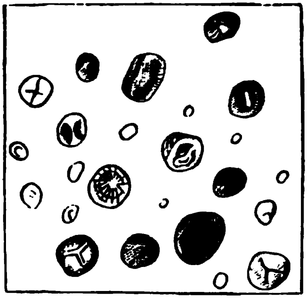


Fig. 5.—Starches.

Cane-sugar is the sweetest of all the sugars, and is that commonly used as food. It is obtained from the sugar-cane, the sorghum plant, the beet root, and the maple-tree. Grape-sugar is found in most fruits and in honey. Milk-sugar gives to milk its sweetness. A sugar resembling grape-sugar, called *glucose*, is very extensively manufactured chemically, by boiling the starch of corn or potatoes with sulphuric acid. Glucose cannot be considered a perfect substitute for natural sugar.

39. **Albumen.**—The white of an egg is almost pure *albumen*. All true foods contain elements which in many respects resemble albumen and serve the same purposes in the body, and so are termed *albuminous elements*. For convenience, we shall apply the term *albumen* to any or all of them. The lean portion of flesh and the *caseine* of milk are forms of animal albumen. All vegetable foods also contain albumen. Caseine, for example, is found in peas and beans, as well as in milk. One of the most important of all the albumens is *gluten*, which is found in wheat, rye, and barley.

40. **Fats.**—Oil, or fat, is found in both animal and vegetable foods. The principal animal fats used as food are butter, lard, suet, and tallow. Vegetable oils are

chiefly derived from oily fruits, as the olive, from nuts, and from various seeds. A very considerable quantity of fat is found in corn and oats.

41. **Salts.** — When a portion of animal or vegetable food is burned, there is left a residue of ashes, made up of inorganic or mineral elements. These are the so-called *salts* of the food. They do not exist in the food in the form in which they are found in its ashes, but in an organized form. The most important source of salts is the grains. Wheat, oats, barley, corn, and rye contain an abundant supply of this element, as do the potato and most other vegetables. The salts also exist in milk in good proportion.

42. **Indigestible Elements.** — All vegetable foods contain more or less of a woody substance, called *cellulose.* The bran of wheat belongs to this class of elements. Cellulose is not to any extent digestible, but it serves an important purpose in giving bulk to the food. The connective tissue elements of flesh foods—the ligaments, tendons, etc.—are hard to digest, and afford little or no nourishment.

In addition to the several elements mentioned, all food substances contain certain flavoring matters.

43. **Condiments.** — A condiment is an article which possesses little or no food value, but is added to food for the purpose of imparting to it a characteristic flavor. The condiments most commonly used in this country are mustard, pepper, ginger, spices, pepper-sauce, Worcestershire and other hot sauces, and vinegar. All condiments possess irritating or stimulating qualities. They stimulate the appetite, and act as whips to the stomach and other digestive organs, and are thus injurious.

44. **Food Substances.** — The several food elements

which we have been considering are not, in any proper sense, to be regarded as food. An animal fed exclusively upon any one of them soon acquires such a disgust for its food that it will refuse to taste it, even though starving, and sooner or later dies. Gluten is the only exception to this rule. A true food contains various elements, which are combined in varying proportions in different foods. Let us now briefly notice some of the leading food substances.

45. **Foods of Animal Origin.** — Chief among animal foods is *milk*, the natural diet of most young animals. Milk contains the elements of nutrition in proper proportion, and will sustain life for an indefinite period. The chief albuminous element of milk is *caseine*. The white color of milk is due to the fact that it contains a considerable amount of fat or oil in a state of emulsion, or division into minute drops. When milk is allowed to stand for a few hours, the oily particles collect at the top, constituting the cream. By churning, the little drops are made to unite, producing *butter*. The ease with which it is digested renders milk a most suitable food for the young. It is, indeed, with rare exceptions, a most wholesome food for persons of all ages.

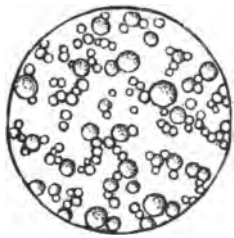


Fig. 6.—Milk Globules.

46. **Cheese** is made from milk by adding rennet, which separates the caseine and fat from the whey. Cheese undergoes partial decomposition in the process of "curing," and is on this account much less wholesome than fresh milk. It is difficult to digest, and

likely to interfere with the digestion of other foods. Sometimes a peculiar fermentation takes place in cheese, which produces a very poisonous substance, known as *tyrotoxicon*. Very serious and sometimes fatal illness often results from the use of such cheese. This poison is destroyed by heat. On this account cheese is rendered less dangerous by cooking, while at the same time it is also made more digestible.

47. **Flesh.** — The flesh of the ox, sheep, or hog, is more largely used as food in this and most other civilized countries than any other kinds of flesh food. *Mutton* is not so well relished by some, but is nearly as nourishing as beef and equally easy to digest. *Pork* contains much fat, is difficult to digest, is likely to be diseased, and must be regarded as an inferior food. The Jews in ancient times were forbidden to eat the flesh of the hog, and still abstain from the use of pork, doubtless for good reasons. The flesh of *deer* and other *wild game*, while usually less tender than that of stall-fattened animals, is more wholesome if eaten when fresh, on account of the healthier conditions of life which wild animals usually enjoy. Game is often allowed to become almost putrid before it is eaten. Such flesh is exceedingly unwholesome. *Veal*, like the flesh of all very young animals, is difficult to digest, and can not be recommended as food.

48. **Fish and Fowl.** — The nutritive value of fish and fowl is not quite equal to that of beef or mutton, but when properly cooked they are relished by most persons, and possess considerable value as foods.

49. **Shell-fish** contain very little nutriment, although some of them, oysters in particular, are in very great favor as table delicacies. All shell-fish are scavengers,

however, and are sometimes poisonous. Frogs, lobsters, shrimps, sea-crabs, etc., are by many considered delicate eating, but can not be regarded as really first-class foods. The oyster is easily digested, though it does not possess the power to digest itself, nor to aid digestion when eaten raw, as many persons suppose. The oyster is a scavenger in its habits, and when the beds in which oysters grow are located in such a manner as to be reached by the impure matters carried into the sea by the sewers of a large city, they sometimes become diseased, and produce serious illness when eaten.

50. **Eggs.** — An egg contains within itself every element needed for the support of the body, and has the advantage, when properly cooked, of being one of the most easily digested of foods, and one of very high nutritive value.

51. **Salted and Smoked Meats.** — Most kinds of flesh foods are preserved by salting. The process of salting hardens the tissues and renders them difficult to digest. Smoked meats and fish are also hard to digest.

52. **Vegetable Foods.** — Vegetable foods are the original source of the nutritive elements contained in flesh foods; hence we should expect them to furnish all the elements of nutrition, and in good proportions. This is the case with the best vegetable foods.

53. **Fruits, Grains, Vegetables.** — Vegetable foods are usually divided into three classes—*fruits*, *grains*, and *vegetables*. *Fruits* comprise fleshy seeds and seed-bearing portions of plants, such as the apple, strawberry, and plum, each of which represents a different class of fruits. Melons and nuts are also fruits. The *grains* comprise those seeds used as foods which are produced

by grass-like plants, as wheat, oats, rye, barley, corn, and rice. Allied to this class are the edible seeds of pod-bearing plants, the chief of which are peas, beans, and lentils. The grains are the most nourishing of all foods, and contain the elements of food in the best proportion. Fruits, grains, and milk constitute a perfect dietary, and one particularly suitable for young persons, and for students and other brain-workers.

Those parts of plants used as food, other than seeds or fruits, such as leaves, stems, roots, buds, and flowers, are called *vegetables*. The nutritive value of vegetables is much less than that of grains. The potato, one of the most valuable of all vegetables, is three-fourths water, and contains only about two per cent. of albuminous elements. The starch of vegetables is more difficult to digest than that of grains and fruits, and the large amount of woody matter contained in most vegetables adds to their indigestibility, so that they must be regarded, in general, as much inferior to fruits and grains as foods.

54. **The Natural Diet of Man.**—It is probable that the diet of the human family at first consisted almost wholly of fruits, grains, milk, and a few vegetables. History informs us that the dietary of the ancient Egyptians, Assyrians, and the early Greeks and Romans was of this simple character, and the same primitive diet is still practically adhered to by fully two-thirds of the inhabitants of the globe. In densely populated countries, such as Japan and China, the dietary is necessarily almost exclusively vegetarian in character. The peasantry of France, Italy, and Spain, and other continental European countries, employ flesh so sparingly in their dietary that they may be said to use it as a

luxury rather than as a food. Human life and health may be well maintained upon vegetable food.

55. **Uses of the Several Food Elements.**—The various food elements serve different purposes in the body. Sugar, starch, and fat form adipose tissue, and in the form of fat enter into the composition of nearly all the tissues of the body. They are of essential service to the body in the production of heat and force. The different forms of albumen nourish especially the brain, nerves, muscles, glands, and other highly active tissues of the body. The salts are largely used in nourishing the bones. They are also required by the brain and the nerves, as well as by other tissues. The indigestible elements give necessary bulk to the food.

SUMMARY.

1. *Foods* supply material to replenish the tissues or to support the vital functions.
2. A *poison* is a substance which is not a food, and which is injurious to the body.
3. Man and other animals subsist upon *organized* food.
4. Plants are the only real food producers.
5. There are six food elements—*starch, albumen, fats, sugars, salts, and indigestible elements.*
6. *Condiments* are flavors, not foods, and generally harmful.
7. Starch, sugars, and fats nourish adipose tissue, and maintain heat and force.
8. Albumen nourishes the active tissues, especially the muscles, brain, and nerves.
9. The salts nourish the bones and the nerve tissues.
10. The indigestible elements give necessary bulk to the food.

CHAPTER V.

DRINKS.

56. Water is the only substance that will quench thirst. Other drinks consist of solids dissolved in water. The importance of water may be inferred from the fact that it constitutes more than three-fourths of the entire weight of the body.

57. **Uses of Water.** — Water is of service to the body chiefly in the following ways: 1. To soften the food in its preparation by cooking; 2. To carry the dissolved food in the blood to the various parts of the body; 3. To dissolve and remove the waste elements of the tissues; 4. To carry away by evaporation from the surface any excess of heat which may be generated, thus regulating the temperature of the body.

58. **Pure Water.** — Absolutely pure water does not exist in nature, but may be obtained by distillation. Ordinary water contains air and other gases, together with various substances derived from the air and the soil. Some of these substances are harmless; others are very injurious when taken into the system in any but very small quantities.

59. **The Impurities of Water.** — Dangerous substances, when present in water, are chiefly derived from the soil. These impurities are of two kinds, inorganic or mineral matters, and organic or organized substances.

Inorganic impurities are chiefly made up of various

compounds of lime, magnesia, soda, potash, iron, etc., and chloride of sodium, or common salt. The salts of lime and magnesia cause water to be *hard*, and show their presence by forming a curd with soap.

60. **Mineral Matters.** — Mineral waters are usually obtained from springs or artesian wells, and contain an unusually large proportion of inorganic impurities, sometimes amounting to several ounces per gallon. As a rule, the continued use of mineral water, notwithstanding the benefit which may be derived from its temporary or occasional use, is in some measure detrimental to health.

61. **Poisoning from Lead or Zinc.** — Lead pipes are objectionable for the conveyance of water which is to be used for cooking or drinking purposes. If one is temporarily obliged to use water from lead pipes, the danger of poisoning may be greatly lessened by allowing the water to run until that which has stood in the pipe has escaped, and fresh water has entered from the street main.

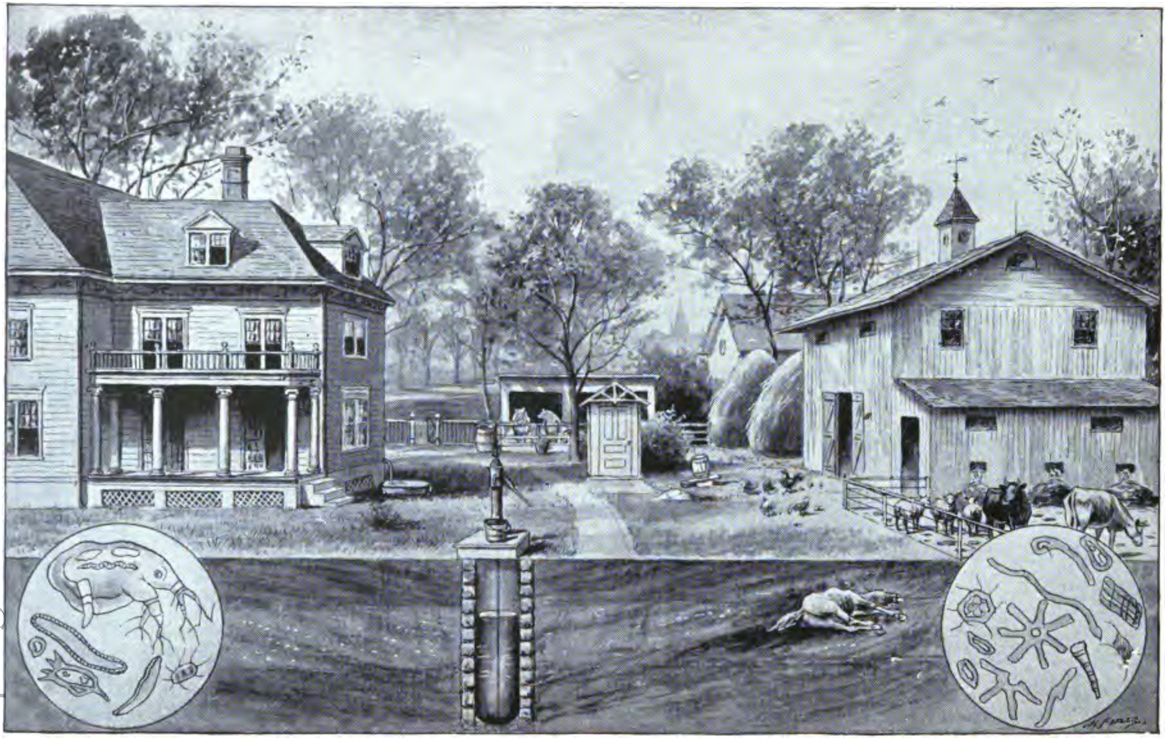
Lead poisoning sometimes occurs from the use of cooking utensils made of a poor quality of tin containing lead. Some foods, and especially acid fruits, acquire poisonous properties when cooked in zinc or galvanized-iron vessels. The prominent symptoms of lead poisoning are chronic pains in the bowels, inactive bowels, loss of appetite, wrist drop, and a blue line at the edge of the gums.

62. **Germs.** — The organic and organized matters found in impure water consist of decomposing animal or vegetable substances, and various forms of microscopic life. Of the latter, the most important, because the most dangerous to life, are certain minute organisms known

as *germs*. Although the smallest of all living forms, germs are the most destructive and dangerous of all enemies to life and health. Their power for mischief depends chiefly upon two things: 1. Their ability to

Fig. 7.—A DROP OF IMPURE WATER. (*Magnified.*)

manufacture poisons of a peculiarly deadly character; 2. The amazing rapidity of their development. Some germs, under favorable conditions, double in number every fifteen minutes. Estimate the number which, at this rate, might arise from a single germ in twenty-four hours! All processes of fermentation, decay, and putrefaction, in animal and vegetable substances, are set up and carried on by different species of germs. Germs



AIR AND WATER CONTAMINATION.

PLATE II.

–A.

are thus of immense service in reducing to dust the dead bodies of plants and animals.

Typhoid-fever, cholera, yellow-fever, and many other infectious, or "catching," diseases are produced and communicated by germs. These organisms are possessed of great vitality. The extreme cold of the Arctic regions does not destroy them. They may be widely scattered in bodies of water, or dispersed in the air in a dry state, and yet retain their destructive properties. Great care should be taken to avoid contact with any person suffering from a contagious or infectious disease. Such persons should be separated from all others except the necessary nurses, and disinfectants should be used under the direction of a physician. By this means the spreading of contagious diseases may be prevented.

63. **Sources of Organic Impurities in Water.**—The chief sources of organic impurities in well-water are vaults, cesspools, and drains. These reservoirs of filth frequently saturate the earth to a considerable distance around them. Water falling in rains soaks into the earth, and in passing through the soil becomes contaminated. At length it finds its way into wells near by. Dug wells are constantly being poisoned in this manner.

A cesspool or vault which is not perfectly water-tight —and one which is made water-tight is certain to leak sooner or later—may at any time contaminate a well which is located on the same or an adjoining village lot of ordinary size, and may even extend its poisonous influence much farther. This remark refers, of course, to dug wells, which always receive more or less surface-water. Any considerable mass of decomposing matter near a well is a source of danger.

Dead animals buried near a well, or decomposing mat-

ters upon the surface, may be a source of contamination. It is also believed that the water of wells in the vicinity of cemeteries is not infrequently poisoned by them. *Cistern-water* is sometimes contaminated by cesspools or leaking drains, or by sewers through connecting overflow pipes. Water stored in wooden tanks or casks soon becomes quite impure.

Rain-water usually contains more or less organic matter. The first rain that falls at the beginning of a shower washes from the roof dust and other filth which has been deposited upon it. In falling through the air, the rain also collects germs and microscopic forms of life, dust, fragments of insects, soot, etc. Cistern-water usually contains sufficient organic matter to support multitudes of low forms of life. *Spring-water*, as well as the water of wells, may be contaminated by decomposing matter from the immediate vicinity or from a distance.

The water of streams, lakes, and indeed all natural waters, are more or less liable to contamination.

64. **Impure Ice.**—Ice formed upon impure water is also impure, and often becomes a source of serious disease. Ice collected from stagnant ponds, or from rivers or small lakes into which sewers empty, should never be used for drinking purposes, nor in food refrigerators.

65. **To Detect Bad Water.**—Pure water is colorless, odorless, and tasteless; but water may be dangerously contaminated and yet be colorless and odorless, and have no perceptible flavor. Dangerous impurities may usually be detected by the following simple method:

Nearly fill a clean two-ounce vial with water to be tested. Add a small lump of pure white sugar. Cork and put in a warm place. If the solution becomes turbid in a few days, the water is unwholesome.

66. **Bad Effects of Impure Water.**—The use, for a considerable time, of water containing *inorganic* impurities, as very hard water, produces different forms of dyspepsia, and disorders of the liver, kidneys, and bladder. *Organic* impurities in water may give rise to a large number of serious and even fatal maladies. Typhoid-fever, cholera, dysentery, and other dangerous diseases are spread by the use of contaminated water.

Intestinal parasites are sometimes introduced into the body through impure water containing their embryos or eggs. River-water is especially liable to contamination of this sort, and should never be used without boiling, even if chemical tests show no evidence of organic impurities.

Most physicians have met with cases in which persons have suffered long and dangerous and even fatal illness from using contaminated water. Not long ago more than a thousand persons living in a small town in Pennsylvania were stricken down with typhoid-fever. The epidemic was traced to contamination of the drinking-water from a single case of the disease. Sometimes the infection is conveyed by milk which has been adulterated with foul water. The washing of milk-cans with foul water may infect the milk, and render it capable of exciting typhoid-fever and other diseases. An epidemic of typhoid-fever occurred in the State of New York, which was traced to the use of milk from a dairy in which the milk cans were wiped with cloths which hung in a room next to one in which was a patient sick with this disease. It is probable, also, that cows may become infected through the drinking of impure water, and thus communicate it to human beings through milk; hence the same care should be taken to secure pure water for domestic animals as for human beings.

67. **Purification of Water.**—Water which is known to be dangerous to health on account of contamination with organic matter should be avoided altogether. Water which is only slightly impure may be cleansed by first *boiling* thoroughly and then *filtering*. Always boil water suspected of being impure. The boiling will destroy animalcules and germs, and proper filtration will remove decomposing matter and sediment. Filters are of little use, however, unless made of good vegetable or animal charcoal. Those made of sand and porous stone simply strain the water without destroying the organic matter. No filter is germ proof.

It is a popular error that water, no matter how impure, is made pure by passing through the soil. The action of the soil in this respect is very limited. The soil readily becomes saturated with impurities, and then water passing through it is rendered more impure instead of being improved. It is also erroneous to suppose that running water purifies itself so quickly that it may be safely used when at the same time receiving filth from drains or sewers. Such impurities have been traced in running streams for many miles.

68. **Care of Filters.**—The filtering substance must be renewed occasionally, and the filter should be allowed to become empty every day or two so as to renew its supply of oxygen from the air, upon which its power to destroy organic matter depends. Foul-smelling water and very hard water should never be put into a filter. Hard water, in which the hardness is due to the presence of lime, may be softened by boiling.

69. **The Best Water.**—The purest water is undoubtedly the best. Water, to be wholesome, must be free from organic impurities, and should contain but a small

amount of inorganic salts. In limestone regions, where all well and spring water is hard, cistern-water is the best to be obtained. An abundant supply of rain-water may be secured if none is wasted, as the roof of an ordinary house will collect a sufficient amount to supply a single family. Cistern-water should always be filtered, and when a perceptible odor is present, should be boiled before filtering.

70. **Wells.**—In most country districts the water supply for domestic purposes is furnished by wells. The water of shallow wells is generally softer, but more liable to contamination with organic impurities, than that of deep wells. The best wells are those made by sinking an iron pipe into the ground until it penetrates for some distance, or passes through, a stratum of rock or impervious clay. What is known as the "second water" is thus reached, which, besides being reasonably secure against danger of contamination, affords a more plentiful and constant supply than that obtained from dug wells.

71. **Water as a Beverage.**—Other beverages than water are useful as drinks just in proportion to the amount of water and the harmlessness of the other substances which they contain. The amount of water required daily in food and drink is from three to five pints. The amount which must be taken as a drink depends upon the character of the food. If fluid food, such as soup and milk, is largely used, together with juicy fruits, nearly or quite the whole amount of fluid necessary may be taken in the food. It is often better to take water quite warm. Very cold or iced water should never be taken at meals, nor when the body is heated, nor in large quantities at any time.

Hot water is, as a rule, preferable to cold water as a beverage. It quenches thirst more quickly than cold water, because it is more readily absorbed. Cold water hinders digestion, while hot water, in moderate quantities, aids digestion. Water which has been boiled is free from germs. It is never prudent to drink water which has not been boiled, unless it is known to be from a pure source.

The free use of water and juicy fruits, especially in the warm season of the year, is an important means of maintaining health, and preventing attacks of sick-headache, biliousness, and similar disorders.

72. **Unwholesome Drinks.**—The danger of using impure water is sometimes offered as an apology for the use of beer and other alcoholic drinks. This is certainly a very poor excuse. Beer is simply a mixture of water with alcohol and other substances, and it not infrequently happens that impure water is used in its manufacture. It thus appears that one who seeks to avoid danger from impure water by using beer doubles the danger instead of diminishing it. The folly of this method of avoiding the danger from impure water is still more apparent when we remember the fact that beer is sometimes adulterated with very poisonous substances, which are more harmful even than alcohol.

Beer, *ale*, *wine*, and other *alcoholic drinks* will not take the place of water, since the alcohol which they introduce into the system produces a feverish condition, by which there is created a demand for more water than the system naturally requires; thus the thirst may be increased rather than quenched. Mead, small-beer, and similar drinks only differ from other alcoholic drinks in the amount of alcohol which they contain, and are not

proper substitutes for water. One great danger in the use of these beverages is the fact that they create an appetite for stronger alcoholic drinks. Alcoholic liquors are sometimes added to the drinks sold at soda fountains, making some care necessary in the use of these popular beverages.

Tea and *coffee* are often used as substitutes for water, but are much inferior to the latter for quenching thirst. They are undoubtedly to some extent harmful, and when freely used may become a source of serious disease. The excuse that impure water is less dangerous if taken in the form of tea and coffee has some slight foundation, since the most dangerous impurities of water are destroyed by boiling. It is evident, however, that water may be boiled without the addition of tea or coffee.

SUMMARY.

1. Water is the only substance that will quench thirst.
2. Uses of water: To soften the food; to convey digested food into the blood; to remove waste matters from the tissues; to cool the body by evaporation from the skin.
3. Two kinds of impurities are found in water, *inorganic* and *organic* or *organized*, the latter the more dangerous.
4. The most dangerous of all impurities are *germs*.
5. The chief sources of germs are *vaults*, *cesspools*, and *drains*.
6. Ice is impure if obtained from impure water.
7. Pure water is *tasteless*, *colorless*, *odorless*.
8. Impurities in water may be detected by proper tests.
9. Impure water may be purified by *boiling* and *filtering*.
10. Wells should be so made as to afford security against contamination.
11. The abundant use of pure water in some form is conducive to health.
12. Such unwholesome drinks as beer, wine, cider, tea, and coffee are not proper substitutes for water.

CHAPTER VI.

THE ORGANS OF DIGESTION.

73. The process by which food is rendered soluble and capable of being absorbed into the body is called digestion. All animals digest; indeed, plants as well as animals prepare their food for use by a digestive process which is carried on in their leaves.

74. **The Alimentary Canal.**—The process of digestion is chiefly performed in a long tortuous tube called the alimentary canal, which is from twenty-five to thirty feet in length, and reaches from the mouth to the lower part of the trunk.

75. **The Digestive Organs** consist of this canal and other organs arranged along and closely connected with it, including various glands. The latter produce peculiar fluids, by which the food is changed in several very remarkable ways, as we shall learn presently. The several organs which take part in the process of digestion may be named as follows: *Mouth, tongue, teeth, salivary glands, œsophagus, stomach, small intestines, colon, liver, and pancreas.* (The relative position of the liver, stomach, and intestines is well shown in the cut on page 47.)

76. **The Mouth.** — The cavity of the *mouth* is the expanded upper portion of the alimentary canal. It contains the *teeth* and the *tongue*, and receives small ducts or canals from the three pairs of *salivary glands* closely

connected with it. These glands produce a fluid known as *saliva*. At the back part of the mouth are found, one on each side of the tonsils, glands which help to form the saliva. The saliva contains an active principle, *ptyalin*.

Fig. 8.—The Salivary Glands.

77. **The Teeth.** — A tooth presents three parts for examination: The portion which is seen above the gum, called the *crown;* the portion which is embedded in the jaw, the *root;* and the narrowed portion which joins these two parts, called the *neck.* The interior of the tooth is filled with a fleshy substance, the *pulp*, containing the blood-vessels and the nerves, which nourish the tooth and give it sensibility. The body of the tooth is made up of a tissue resembling bone. The portion which projects from the gum is covered by a very hard, smooth substance, called *enamel*, which is so brittle as to be easily broken by violent contact with hard substances.

78. **Temporary Teeth.** — The teeth which appear in infancy and early childhood are called *temporary* or

milk teeth. These teeth usually make their appearance between the ages of seven months and two years. They are twenty in number, and consist, in each jaw, of four front teeth, or *incisors*, two *cuspids*, one on each side of the incisors, and four *molars*, or double teeth, two on each side.

79. **Permanent Teeth.** — At the age of six to seven years the temporary teeth begin to give place to the

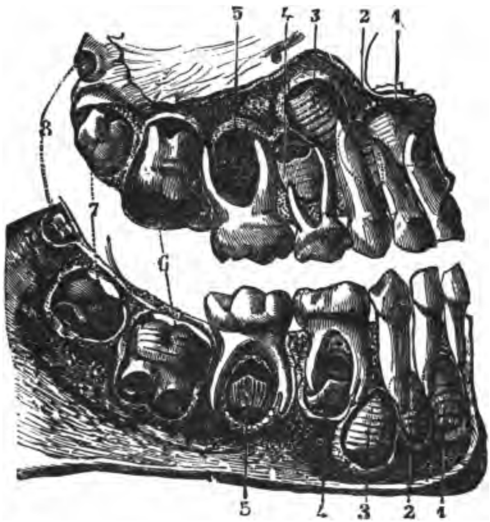


Fig. 9.—The Temporary or Milk Teeth.

The rudiments of the Permanent Teeth are shown at 1, 2, 3, 4, 5, 6, 7, and 8.

permanent set, which, when complete, at the age of seventeen to twenty, numbers thirty-two, each jaw containing, in addition to those of the temporary set, four small double teeth, or *bicuspids*, and two additional molars,

the so-called *wisdom teeth*. The last of the temporary teeth should give place to the permanent ones not later than the twelfth year.

80. **The Œsophagus.** — In the act of swallowing the food passes from the mouth downward through a narrow passage about nine inches in length, commonly called the *œsophagus*, or *meat-pipe*. The walls of this canal are made up in part of muscles, by the aid of which the food is carried through it. When empty, its sides lie in contact with each other. At its lower end a circular muscle guards the opening into the stomach.

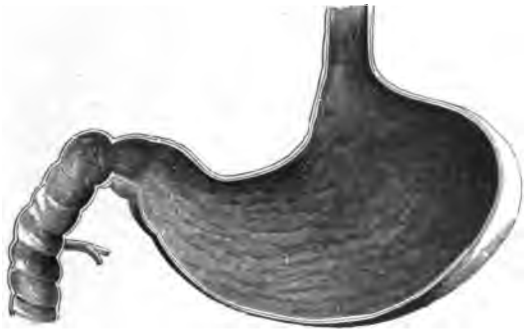


Fig. 10.—The Stomach.

81. **The Stomach.** — This is a dilated portion of the alimentary canal, somewhat pear-shaped in form, and capable of holding from one to two quarts. The walls of the stomach, like those of the entire digestive canal, are made up largely of thin layers of muscle, by means of which it is able to change its size and shape, and so to act upon the food as to produce a sort of churning action.

82. **The Peptic Glands.** — The lining membrane of the stomach, when examined with a microscope, is found

to present multitudes of minute openings, each of which is found, on further examination, to communicate with a narrow tube which is embedded in the walls of the stomach. This little pocket is lined with minute living cells, which, during the digestion of a meal, are engaged in making an important digestive fluid, the *gastric juice.* The gastric juice is intensely acid. It contains two digestive principles, *pepsin* and *rennin.*

83. **The Pylorus.**—Each end of the stomach is guarded by a circular muscle. That at the lower or right end is known as the *pylorus.* By means of these muscles, the openings of the stomach are kept tightly closed while the process of digestion is going on.

84. **The Small Intestine.**—This portion of the alimentary canal is about twenty feet in length, reaching from the stomach to the large intestine, which it joins at the lower-right portion of the cavity of the abdomen. The walls of the intestine are muscular, like those of the stomach. Its mucous lining contains many glands, which produce an alkaline digestive fluid known as *intestinal juice*, and is covered with *giant cells* which defend the body against germs. During digestion, the muscular walls of the intestines are in constant motion.

85. **The Absorbents.**—The mucous membrane of the small intestine presents numerous folds, and also contains peculiar structures for aiding *absorption*—the *villi.* The villi are hair-like projections of mucous membrane, which hang out into the cavity of the intestine. Each villus contains blood-vessels and lymph-channels.

86. **The Large Intestine, or Colon.**—This portion of the alimentary canal is about five feet in length, and is much larger in diameter than the small intestine. It begins at the lower right side of the abdominal cavity,

where it is joined by the small intestine. From this point the *colon* passes upward to the lower border of the ribs, crosses over to the left side, then passes down to the lower left portion of the abdomen, and thence backward, finally terminating in the *rectum*.

87. **The Liver.** — Lying chiefly at the right side, just above the lower border of the ribs, and partly covering the stomach, is the largest gland in the body, the *liver*. At the under side of the liver is a sac, or pouch, known as the *gall-bladder*, in which is stored up a fluid formed by the liver; this fluid is called the *bile*. A short canal, or duct, connects both the gall-bladder and the liver with the small intestine at a point a few inches below the stomach.

Fig. 11.—The Alimentary Canal.

88. **The Bile.**—Human bile is alkaline, somewhat viscid, and of a golden-brown color when fresh. When vomited, bile is often green or yellow, as the result of changes produced in the stomach by contact with the acid gastric juice. The bile of the ox is of a greenish color.

A remarkable fact in relation to the structure of the liver is that it is supplied with two sets of blood-vessels.

The extra system of vessels brings to the liver the blood from the stomach, intestines, and other digestive organs, and constitutes the *portal circulation.*

89. **The Pancreas.** — Just behind the stomach is a long curiously shaped gland, known as the *pancreas*, which secretes the *pancreatic juice.* This is a fluid much like saliva. It is produced during the digestion of a meal, and is poured into the small intestine through a duct which joins that from the liver, and with it opens into the intestinal canal four or five inches below the stomach.

The pancreatic juice contains four active principles, *amylopsin*, *trypsin*, *steapsin*, and a *milk-curdling ferment.*

SUMMARY.

1. *Digestion* is a process by which the various food substances are dissolved, and prepared for absorption into the blood.

2. Both plants and animals digest.

3. The digestive apparatus consists of the *alimentary canal* and various organs connected with it—the *mouth, teeth, salivary glands, œsophagus, stomach, small intestines, colon, liver,* and *pancreas.*

4. There are two sets of teeth—the *temporary* or *milk teeth,* and the *permanent teeth.*

5. The *salivary glands* produce the *saliva.*

6. The *peptic glands* of the stomach produce an acid digestive fluid, the *gastric juice.*

7. The *intestinal glands* produce the *intestinal juice.*

8. The liver produces an alkaline fluid, the *bile.*

9. The liver has two sets of blood-vessels. The extra set collects blood from the veins of the stomach, intestines, pancreas, and spleen, which together form the *portal circulation.*

10. The pancreas produces the *pancreatic juice.*

11. There are five digestive fluids—the *saliva,* the *gastric juice,* the *bile,* the *pancreatic fluid,* the *intestinal juice.*

CHAPTER VII.

THE DIGESTIVE FLUIDS.

90. **The Digestive Fluids.** — In studying the organs of digestion, we learned that there are five digestive fluids, viz.: the saliva, the gastric juice, the bile, the pancreatic juice, and the intestinal juice. In the preceding chapter we have learned that there are five digestible food elements, viz.: starch, albumen,* fats, sugars, and salts. Let us now study carefully the use of each digestive fluid in relation to the various food elements.

Much of the information which has been gained respecting the action of the stomach upon the food is due to the persevering and accurate observations of Dr. Beaumont, a surgeon in the American army, who, in 1822, while stationed in what was then known as "Michigan Territory," was called upon to take charge of the case of a young Canadian by the name of Alexis St. Martin, who had been accidentally wounded in the side by the discharge of a musket loaded with shot, at a distance of one yard from his body. A portion of flesh as large as a man's hand was torn away from his side, leaving large openings into both the stomach and the chest. The opening communicating with the chest cavity finally

* The word *albumen* is used to represent all the albuminous elements of the food—albumen, gluten, caseine, etc.

closed up entirely, but the opening into the stomach remained. Immediately after his recovery it was about two and one-half inches in diameter. Whatever was swallowed passed out through this opening, making it necessary to wear a pad for some time to close the opening. In time nature remedied the difficulty by growing over the opening, upon the inside, a loose fold of membrane which effectually closed it, but at the same time could be easily pushed aside, thus allowing a full view of the interior of the stomach.

Great and important additions to our knowledge of digestion have been made recently by the use of the "stomach tube," a flexible rubber tube, by means of which digesting food may be removed from the stomach for chemical examination. The facts thus learned give us more positive and definite information respecting the work of the stomach and the digestive properties of food than we have previously possessed, and throw great light upon the hygiene of digestion.

91. **What the Saliva Digests.** — A dry crust of bread, chewed for some minutes, becomes sweet. This is due to the fact that the saliva contains a peculiar principle which, when brought into contact with boiled starch, converts it into grape-sugar. This conversion into sugar constitutes the digestion of starch. It is essential, however, that the starch should be cooked, as the saliva cannot readily digest raw starch. Each little granule is surrounded by a thin shell of woody matter, or cellulose, which the saliva cannot dissolve. The saliva also stimulates the stomach to secrete gastric juice.

92. **What the Gastric Juice Digests.** — Pepsin, one of the active principles of the gastric juice, acts upon the albuminous elements of the food, such as egg-

albumen, the fibrine of meat, gluten of grains, caseine of milk, etc. By its action all of these various substances are converted into one simple substance, known as *peptone*, which is readily absorbed into the blood, while undigested albumen cannot be absorbed to any great extent, and, if absorbed, would be of no use in the system. The gastric juice prepares the food for further digestion by dissolving the substances by which the various elements of the food are held together. Rennin curdles milk.

Carbolic acid, common salt, and numerous other substances are called antiseptics, because they prevent fermentation or decay. The gastric juice and the bile possess this remarkable property. A dog was fed with putrid meat. On being killed, an hour after, the meat, which had been extremely offensive, was apparently perfectly fresh. This property of the gastric juice is exceedingly important, as it prevents decay or fermentation in the stomach before digestion can take place.

93. **What the Bile Digests.** — Like the saliva and the gastric juice, the bile digests but a single one of the digestible food elements. Its action is wholly upon the fatty portions of the food. If oil and water are shaken together in a bottle, they quickly separate when the shaking ceases. Gum-water and oil, when shaken together, form a milky mixture in which the oil and the water do not separate, and which may be diluted with water the same as milk. The bile acts upon fats in the same manner. Such a mixture is called an *emulsion*. Under a microscope, the oil of an emulsion is seen to be divided up into very fine drops or globules.

94. **What the Pancreatic Juice Digests.** — The pancreatic juice digests each of the three principal food

elements — starch, albumen, and fats. Amylopsin converts starch into sugar, trypsin changes albumen into peptone, and steapsin makes an emulsion of the fats. The pancreatic juice does the work of all three of the preceding digestive fluids—the saliva, the gastric juice, and the bile.

95. **What the Intestinal Juice Digests.** — This fluid possesses but one characteristic digestive property. Cane-sugar is ordinarily digested only in the small intestine, and by the action of the intestinal juice. The intestinal juice also digests starch, albumen, and fats, and, together with each of the other digestive fluids, acts upon the salts of the food.

In herbivorous animals, and to a small extent in man, cellulose is digested in the large intestine.

SUMMARY.

1. There are five digestive fluids—saliva, gastric juice, bile, pancreatic juice, intestinal juice.
2. There are five digestible food elements — starch, albumen, fats, sugar, salts.
3. The saliva digests *starch*.
4. The gastric juice digests *albumen*.
5. The bile digests *fats*.
6. The pancreatic juice digests *starch*, *albumen*, and *fats*.
7. The intestinal juice digests *starch*, *albumen*, *fats*, and *cane-sugar*.
8. All the digestive fluids digest the *salts*.
9. Starch is digested by the *saliva*, *pancreatic juice*, and *intestinal juice*.
10. Albumen is digested by the *gastric juice*, *pancreatic juice*, and *intestinal juice*.
11. Fats are digested by the *bile*, *pancreatic juice*, and *intestinal juice*.
12. Cane-sugar is digested by the *intestinal juice* alone.
13. The salts are digested by *all* the digestive fluids.
14. The digestive process changes starch and cane-sugar to grape-sugar, albumen to peptone, fats to emulsion, and dissolves the salts.

CHAPTER VIII.

GENERAL VIEW OF THE DIGESTIVE PROCESS.

96. The digestive process begins the moment a morsel of food enters the mouth, and continues throughout the entire length of the alimentary canal, or until the digestible portions of the food have been completely digested.

97. **Mastication.**—The first act in the digestive process is mastication, or chewing the food, the purpose of which is to crush the food and divide it into small particles, so that the various digestive fluids may easily and promptly come into contact with every part of it.

98. **Salivary Digestion.**—The saliva softens the food, and thus prepares it for the action of the other digestive fluids. It also acts upon the starch, converting a portion of it into sugar.

99. **Deglutition, or Swallowing.**—In the act of swallowing, the food does not drop down through an open tube, but is seized by the muscles at the back of the mouth, and is carried down into the stomach by the œsophagus.

100. **Stomach Digestion.**—After receiving the food, the stomach soon begins to pour out the gastric juice, which first makes its appearance in little drops, like beads of sweat upon the face when the perspiration starts. As the quantity increases, the drops run together, trickle down the sides of the stomach, and mingle

with the food. The muscular walls of the stomach contract upon the food, moving it about with a sort of churning action, thoroughly mixing the gastric juice with the food. During this process both the openings of the stomach are tightly closed. The gastric juice softens the food, digests albumen, and coagulates milk. The saliva continues its action upon starch for some time after the food reaches the stomach.

101. **Action of the Pylorus.**—After the food has remained in the stomach from one to three hours, or even longer, if the digestion is slow or indigestible foods have been eaten, the contractions of the stomach become so vigorous that the more fluid portions of the food are squeezed out through the pylorus, thus escaping into the intestine. The pylorus does not exercise a species of intelligence in the selection of the food, as was once supposed. The increasing acidity of the contents of the stomach causes its muscular walls to contract with increasing vigor, until finally those portions of the food which may be less perfectly broken up, but which the stomach has been unable to digest, are forced through the pylorus.

102. **Intestinal Digestion.**—As it leaves the stomach, the partially digested mass of food is intensely acid, from the large quantity of gastric juice which it contains. Intestinal digestion cannot begin until the food becomes alkaline. The alkaline bile neutralizes the gastric juice, and renders the digesting mass slightly alkaline. The bile also acts upon the fats of the food, converting them into an emulsion. The pancreatic juice converts the starch into sugar, digesting both raw and cooked starch. It also digests fats and albumen. The intestinal juice continues the work begun by the other digestive fluids, and digests cane-sugar.

103. **Other Uses of the Digestive Fluids.** — In addition to the uses of which we have already learned, several of the digestive fluids possess other interesting properties. The saliva aids the stomach, by stimulating its glands to make gastric juice. The gastric juice and the bile are excellent antiseptics, by which the food is preserved from fermentation while undergoing digestion. The bile also stimulates the movements of the intestines by which the food is moved along, and aids absorption. It is a remarkable and interesting fact that a fluid so useful as the bile should be at the same time largely composed of waste matters which are being removed from the body. This is an illustration of the wonderful economy shown by Nature in her operations.

104. **Peristaltic Action.**—The food is moved along the alimentary canal, from the stomach downward, by successive contractions of the muscular walls of the intestines, known as *peristaltic movements*, which occur with great regularity during digestion.

105. **Absorption.**—The absorption of the food begins as soon as any portion has been digested. Even in the mouth and the œsophagus a small amount is absorbed. The entire mucous membrane lining the digestive canal is furnished with a rich supply of blood-vessels, by which the greater part of the digested food is absorbed. Absorption is greatly aided by a rhythmical contraction of the villi, which is in effect a sort of pumping action, alternately filling and emptying the lacteal and venous absorbents. The action of the diaphragm in normal breathing also aids absorption by emptying the blood-vessels of the stomach and intestines. During absorption, the digested food is changed into blood.

106. **The Lacteals.**—The walls of the intestines con-

tain certain small vessels called *lacteals*, on account of their white appearance after a meal. This appearance is due to the digested fat which they contain, and which it is their special duty to absorb. The small lacteal vessels unite to form larger ones, all joining at last in one large one about the size of a crow's quill, called the *thoracic duct*, which passes upward and connects with the large veins that return the blood from the left arm.

107. **The Portal Vein.** — The veins of the stomach, intestines, pancreas, and spleen all unite to form one large vein, called the *portal vein.* Instead of emptying, as do other veins, into the large vein which goes to the heart, the portal vein conveys its blood to the liver, through which it is distributed by a special set of vessels. Afterwards it is gathered up by another large vein, and carried to the heart. Thus it appears that all of the food absorbed by the blood-vessels of the stomach and intestines, constituting the greater part of what is digested, is carried to the liver before entering the general circulation.

108. **Liver Digestion.** — The liver not only secretes a digestive fluid, the bile, but it acts upon the food brought to it by the portal vein, and regulates the supply of digested food to the general system. It converts a large share of the grape-sugar and partially digested starch brought to it into liver-starch, commonly termed *glycogen*, which it stores up in its tissues. During the interval between the meals, the liver gradually redigests the glycogen, reconverting it into sugar, and thus supplying it to the blood in small quantities, instead of allowing the entire amount formed in digestion to enter the circulation at once. If too large an amount of sugar entered the blood at once, the system would be

unable to use it all, and would be compelled to get rid of a considerable portion through the kidneys.

The remarkable function by which the liver stores up starch within its tissues is usefully employed as a means of protecting the body from various poisons. When arsenic, mercury, lead, or any other metallic poison is taken into the stomach, any portion absorbed is carried to the liver, which absorbs and retains as much as possible of the poison, and thus protects the rest of the body. The liver treats alcohol and other narcotics in the same manner; and it is doubtless for this reason that the liver suffers so great damage from the use of alcoholic drinks, tobacco, and other narcotic substances. Vegetable poisons and undigested food substances are also destroyed by the liver.

SUMMARY.

1. There are five general divisions of the digestive apparatus—*mouth, stomach, liver, pancreas, intestines.*
2. Corresponding to these there are *five* digestible food elements, which are digested by *five* digestive fluids.
3. There are ten digestive processes — mastication, salivary digestion, deglutition, gastric digestion, biliary digestion, pancreatic digestion, intestinal digestion, peristaltic action, absorption, liver digestion.
4. Besides digesting starch, the saliva softens the food and stimulates the secretion of gastric juice.
5. Besides digesting albumen, the gastric juice preserves the food from fermentation.
6. Besides digesting fats, the bile prevents decay of the food in the bowels, aids absorption, and stimulates peristaltic action.
7. The *lacteals* absorb the digested fat.
8. The veins of the stomach, spleen, pancreas, and intestines unite to form the *portal vein.*

CHAPTER IX.

THE HYGIENE OF DIGESTION.

109. The hygiene of digestion has to do with the *quality* and *quantity* of food eaten, and the *manner* of eating it.

110. **Hasty Eating.** — If the food is eaten too rapidly, it will not be properly divided, and when swallowed in coarse lumps, the digestive fluids cannot readily act upon it. On account of the insufficient mastication, the saliva will be deficient in quantity, and, as a consequence, the starch will not be well digested, and the stomach will not secrete a sufficient amount of gastric juice. It is not well to eat only soft or liquid food, as we are likely to swallow it without proper chewing. Cows fed upon "slops" soon lose their teeth, and become otherwise unhealthy. A considerable proportion of hard food, which requires thorough mastication, should be eaten at every meal.

111. **Drinking Freely at Meals** is harmful, as it not only encourages hasty eating, but dilutes the gastric juice, and thus lessens its activity. The food should be chewed until sufficiently moistened by the saliva to allow it to be swallowed. When large quantities of fluid are taken into the stomach, digestion does not begin until a considerable portion of the fluid has been absorbed. If cold foods or drinks are taken with the meal, such as ice-cream, ice-water, iced milk or tea, the stomach is

chilled, and a long delay in the digestive process is occasioned. Dr. Beaumont noted this fact in his observations upon the process of digestion in St. Martin.

The Indians of Brazil carefully abstain from drinking when eating, and the same custom prevails among many other savage tribes.

112. **Eating between Meals.** — The habit of eating apples, nuts, fruits, confectionery, etc., between meals is exceedingly harmful, and certain to produce loss of appetite and indigestion. The stomach, as well as the muscles and other organs of the body, requires rest. The frequency with which meals should be taken depends somewhat upon the age and occupation of an individual. Infants take their food at short intervals, and, owing to its simple character, are able to digest it very quickly. Adults should not take food more frequently than three times a day; and persons whose employments are sedentary may, in many cases at least, adopt with advantage the plan of the ancient Greeks, who ate but twice a day. The latter custom is quite general among the higher classes in France and Spain, and is gaining ground in this country.

113. **Simplicity in Diet.** — Taking too many kinds of food at a meal is a common fault in well-to-do families, and is a cause of disease of the digestive organs. Those nations are the most hardy and enduring whose dietary is the most simple. The Scotch peasantry live chiefly upon oatmeal, the Irish upon potatoes, milk, and oatmeal, the Italian upon peas, beans, macaroni, and chestnuts; yet all these are noted for remarkable health and endurance. The natives of the Canary Islands, an exceedingly well-developed and vigorous race, subsist almost exclusively upon a food which they call *gofio*,

consisting of parched grain coarsely ground in a mortar and mixed with water.

The stomach cannot well digest a mixture of many different kinds of food at the same meal, though it might digest well any one or two of them if taken alone. The practice of supplementing a hearty dinner by a dessert of rich puddings and sauces is unwholesome, as it not only adds to the more than ample variety of articles already eaten, but leads to overeating.

114. **Eating when Tired.** — It is not well to eat when exhausted by violent exercise, as the system is not prepared to do the work of digestion well. Sleeping immediately after eating is also a harmful practice. The process of digestion cannot well be performed during sleep, and sleep is disturbed by the ineffective efforts of the digestive organs. Hence the well-known evil effects of late suppers.

115. **Eating Too Much.** — Hasty eating is the greatest cause of overeating. When one eats too rapidly, the food is crowded into the stomach so fast that nature has not time to cry "enough," by taking away the appetite before too much has been eaten. When excess of food is taken, the food is likely to ferment or sour before it can be digested. One who eats too much usually feels dull after eating.

116. **How Much Food is Enough?** — The proper quantity for each person to take is what he is able to digest and utilize. This amount varies with each individual, and for the same individual, at different times. The amount needed will vary with the amount of work done—mental or muscular; with the weather or season of the year—more food being required in cold than in warm weather; with the age of an individual—very old

and very young persons requiring less food than those of middle-age. An unperverted appetite, not artificially stimulated, is a safe guide. Drowsiness, dulness, and heaviness at the stomach are indications of excess in eating, and naturally suggest a lessening of the quantity of food, unless the symptoms are known to arise from some other cause.

117. **Cookery.** — Proper cooking of food is a sort of artificial digestion. Each of the food elements, with the exception of fats, is improved by cooking, being changed by the action of heat in much the same way as by the action of the digestive fluids. Fats, on the contrary, are rendered less digestible, especially when exposed to heat for any considerable length of time, or to a high degree of heat even for a brief period, as in frying.

118. **Bread-making.** — From the earliest ages, bread in some form has constituted an important element in the bill of fare of all nations acquainted with the art of bread-making. There are essentially three kinds of bread— leavened bread, unleavened bread, and bread raised from some form of baking-powder. Leavened bread is made by adding yeast to a mixture of flour and water, and allowing it to "rise,"

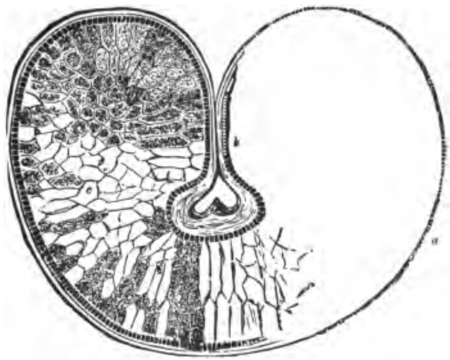


Fig. 12.—A Grain of Wheat.
a. Outer Envelope. *b.* Gluten Layer. *c.* Starch Cells.

or ferment, a process in which a portion of the constituents of the grain is decomposed into alcohol and carbonic acid gas. The gas bubbles up through the dough, and being retained by the tenacious gluten, makes the bread light.

Unleavened bread is made by working into the dough a considerable quantity of air, which expands by the action of the heat, while a portion of the moisture of the loaf is converted into steam. The steam and heated air, in rising through the loaf, form bubbles which make it light.

Baking-powders consist of chemical substances which generate carbonic acid gas when moistened. By mixing them with the flour, the bread is made light in essentially the same way as when fermented.

Unleavened bread, when well made, is by far the most healthful of the three kinds, though the art of making it, which was well known among the ancients, and is still practised by many barbarous tribes, seems to have been nearly lost by civilized nations. The hoe-cake of the South and the beaten bread of Virginia are excellent specimens of unleavened bread.

119. **Bad Cookery.**—While good cookery is an important aid to digestion, bad cookery is as great a hinderance, and is a cause of disease. Frying and other methods of cooking with fats are especially objectionable. As fat is not acted upon either by the saliva or by the gastric juice, a morsel of food which is saturated with fat remains undigested in the stomach, and does not begin to be digested until it reaches the small intestines, and comes in contact with the pancreatic juice and the bile.

The use of pastry, rich cake, hot buttered toast, and similar articles, is objectionable on the same ground.

Hashes, stews, and sausages are usually greasy messes wholly unfit to be eaten. In mince-pies, besides unwholesome condiments and various indigestible ingredients, there is usually more or less alcohol, which renders them doubly objectionable. Imperfectly cooked or raw food, when habitually used, causes indigestion.

120. **Excess of Certain Food Elements.** — When sugar is too freely used, either with food or in the form of sweetmeats or candies, indigestion, and even more serious disease, is likely to result. We should remember that the starch, which constitutes so large a part of our food, is all converted into sugar in the process of digestion, so that a very small amount of sugar will suffice to meet the demands of the system. Fats, when freely used, give rise to indigestion and "biliousness." An excess of albumen from the too free use of meat is harmful. Only a limited amount of this element can be used; any excess is treated as waste matter, and must be removed from the system by the liver and the kidneys. Most persons would enjoy better health by using meat less freely than is usual in this country, and perfect health can be maintained without flesh-food.

121. **Deficiency of Certain Food Elements.** — A diet deficient in any important food element is even more detrimental to health than a diet in which certain elements are in excess. Superfine white flour consists chiefly of the starchy central portion of the grain, the outer layers, which are rich in albuminous elements, having been removed with the bran. The most wholesome flour is wheat meal or Graham flour, or a still more perfect preparation known as "whole-wheat" or "entire-wheat" flour, which contains all the nutritive elements of the grain.

The popular notion that beef-tea and meat extracts contain the nourishing elements of meat in a concentrated form, is a dangerous error. Undoubtedly, many sick persons have been starved by being fed exclusively upon these articles, which are almost wholly composed of waste substances. Professor Claude Bernard, of Paris, found that dogs fed upon meat extract died sooner than those which received only water.

122. **Unripe and Decayed Foods.** — Immature fruits — as unripe apples, pears, peaches, etc.—are exceedingly difficult to digest, and likely to cause serious disease. On the other hand, foods which are over-ripe, or which have begun to decay, are equally objectionable. Animal food with a "high flavor," which is evidence that decomposition has begun, is especially dangerous. Game sent to market without being "drawn," should never be eaten. Cases of poisoning are frequently traced to the use of canned meat which has decomposed as the result of imperfect canning, or after the can has been opened. Fish and oysters are especially liable to this kind of decomposition.

Cheese sometimes undergoes a kind of fermentation which renders it extremely poisonous. Such cheese, when tested with blue "litmus-paper," proves to be acid by turning the paper red. Cheese also frequently contains the young of a fly, familiarly known as "hoppers" or "skippers." The cheese-mite is another parasite of cheese. Cheese is difficult to digest, and hence is a frequent cause of severe illness. Very old cheese is wholly unfit for food.

Sour or stale milk, mouldy bread, or other stale or sour foods, should never be eaten. Boiling milk will destroy any germs which it may contain. During the hot

months the milk fed to young children should always be boiled. A large share of the sickness from which infants suffer may be prevented by this simple means.

123. **Diseased Foods.** — All domestic animals that are used as food are subject to diseases which render their flesh liable to cause sickness if eaten. The process of fattening is frequently productive of disease. Animals are often kept under conditions most unfavorable to health, and thereby become diseased.

The hog is sometimes infested by a parasite called *trichina*. These parasites, when taken into the stomach by eating pork, rapidly increase in numbers, and the young trichinæ soon find their way to all parts of the body. Violent illness, and even death, is often caused in this way. One cannot eat uncooked or imperfectly cooked pork without running the risk of infection by these parasites, which, when once received into the system, are retained during an individual's life. Pork is much less wholesome than most other kinds of flesh, and is more difficult to digest.

Fig. 13.—Trichinæ in Pork.

Meat should always be carefully inspected before it is purchased. If it has a very dark red color, the ani-

mal, when killed, was probably suffering with some sort of fever. A very pale or yellow color in meat indicates an unhealthy condition of the animal—as consumption, scrofula, or jaundice. Small white specks in the flesh indicate the presence of trichinæ, and larger white specks the embryos of the tape-worm. When a knife is drawn through the flesh, if the juice of the meat adheres to it, it should be rejected. Meat which has the slightest taint or odor of decomposition should not be eaten.

The milk of diseased cows is unwholesome, and the same must be said of the milk of cows that are kept in close, unventilated stalls, and do not receive healthful food and proper care. It is quite possible that consumption, which is increasingly prevalent among cows, may be communicated to human beings through the use of the milk of consumptive cows. Milk should on this account invariably be boiled unless known to be from a healthy animal.

Ergot in wheat and rye, *rust* in various grains, and the "*yellows*" in peaches, are examples of disease in vegetable foods which renders them unfit for use.

124. **Adulteration of Foods.**—The adulteration of foods is practised to a very great extent, especially in large cities. Milk is most likely to be adulterated with water, though sometimes various mixtures are added.

In recent years, sugar has become to an enormous extent the subject of adulteration with *glucose*, the artificial sugar made from corn. Very few of the syrups now sold are free from this adulterant, and the cheap sugars are about equally open to suspicion. Honey and maple syrup are often largely adulterated with glucose.

Many of the *fruit flavors* and *jellies* sold in the stores are either wholly artificial or very largely adulterated.

Tea and *coffee* are often adulterated. Ground coffee usually contains almost anything but real coffee, of which it often contains not a particle. *Vinegar* is frequently adulterated with oil of vitriol and other mineral acids.

125. **Indigestible Foods.**—Such indigestible foods as *preserves*, *pickles*, *ices*, etc., are productive of much mischief to the digestive organs, and will be avoided by those who value a good digestion.

126. **Condiments.**—Such irritating and stimulating substances as *mustard*, *pepper*, *pepper-sauce*, and other *condiments* are in no sense foods. They act upon the digestive organs as whips to goad them to the performance of more work than ought to be required of them, and more than they are really able to do. The ultimate result is debility and disease. Condiments also encourage overeating.

Salt is about the only condiment allowable, and this is generally used too freely. Many wild tribes, and most animals, enjoy excellent health without adding salt to their natural food. Vinegar is of doubtful value. It often contains minute creatures known as *vinegar eels*. Lemon-juice or lime-juice is a good substitute. Pickles are wholly unfit for food.

127. **Substances not Foods.**—*Soda*, *saleratus*, *cream of tartar*, and the various baking-powders so commonly used in cookery are all more or less objectionable. Baking-powders often contain *alum*, which renders them still more harmful. The habit of eating clay, charcoal, plaster, chalk, etc., which is sometimes acquired, is very detrimental to health, and may cause fatal illness.

128. **Hygiene of the Bowels.**—The "call of nature" to relieve the bowels should receive prompt attention, and, if possible, at a regular hour each day.

Numerous diseases, some of a very serious character, grow out of the neglect of this duty.

129. **Hygiene of the Teeth.** — First of all, see that they are thoroughly cleansed after each meal by rinsing with water and by the use of a wooden toothpick. Every particle of food must be carefully removed from between the teeth. If allowed to remain, the food decomposes, and causes decay of the teeth. The teeth should also be cleansed each night and morning by means of a soft brush and plenty of water. A little precipitated chalk may be used two or three times a week. Cracking nuts or biting hard substances with the teeth may cause serious mischief, by breaking the tooth or injuring the enamel. Pain in a tooth is an indication of disease, and if it is constant, or recurs frequently, a competent dentist should be consulted. The first beginning of decay should receive prompt attention. A small cavity, if not filled at once, may in a short time become so large as to destroy the tooth. Never sacrifice a tooth if it can be saved.

SUMMARY.

1. The chief errors respecting diet are in relation to the *quantity* and *quality* of food, and the *manner of eating.*
2. We may err in the manner of eating by eating hastily, drinking freely at meals, taking very cold or iced foods or drinks at meals, eating between meals, or too frequently, lack of simplicity in diet, eating when exhausted, or shortly before retiring.
3. We may err as regards the quantity of food by taking either too much or too little.
4. Food, to be of good quality, must be properly cooked; condiments and chemicals are unwholesome; fried or greasy food is very indigestible; food elements must be in right proportion; food must be mature, but not decayed.
5. The bowels must receive regular and prompt attention.
6. The teeth must be properly used, carefully cleansed daily, and filled as soon as decay begins.

CHAPTER X.

ALCOHOLIC DRINKS, TOBACCO, AND OTHER NARCOTICS.

130. **Narcotics** are drugs which have a stupefying effect upon the brain and the nerves. In small doses, many narcotics produce an appearance of increased strength and activity. Some of these drugs on this account have been called *stimulants.* It may be here stated, however, that a stimulant does not increase strength, but rather diminishes strength, as we shall learn in a future chapter. All narcotics, and the so-called stimulants, if taken in sufficient doses, cause insensibility and death. The most injurious articles of this class in common use are *alcohol*, *tobacco*, *opium*, *tea*, and *coffee.* A new drug, even more dangerous than any of the above, has recently come into use. It is known as *cocaine.* It is made from the leaves of the coca-tree, which are used for a beverage in South America, as tea leaves are used in this and other countries. These substances have been aptly called "*vice-drugs.*"

131. **What is Alcohol?** — Alcohol is a chemical substance which has been used in some form from the most ancient times, although known in a pure state for but a few hundred years. As a chemical compound, alcohol is closely related to naphtha and a number of similar substances.

132. **How Alcohol is Produced.** — Unlike grains, fruits, and other food substances, alcohol does not grow.

It is not produced by any plant, tree, or shrub. It is rather the result of death — of a process of decay or *fermentation*, the nature of which we may study with interest and profit.

133. **Fermentation.** — The process of fermentation is the result of the action of a microscopic plant familiarly known as yeast. This curious plant, and the process of fermentation set up by it, serve a useful purpose in the familiar household operation of bread-making. Yeast spores and other germs are constantly present in the air. Atmospheric dust is made up in part of these minute living forms. When these germs come in contact with animal or vegetable substances, under proper conditions as regards warmth and moisture, various changes are produced, the result of which is decomposition or decay. The various forms of mould and mildew are produced by germs. The decay of fruits and vegetables, and the putrefaction of flesh, are due to different species of germs, which produce these particular kinds of decay. Several species of germs are capable of producing the destructive change which we call fermentation. When these germs come into contact with a watery solution containing sugar, fermentation is set up, and the sugar is decomposed into alcohol and carbonic acid gas. The alcohol remains in the solution, while the carbonic acid gas bubbles up through the solution and escapes. If the fermentation continues long enough, the alcohol is decomposed into acetic acid and water, which is commonly known as vinegar. (See Experiment 3, page 271.)

It is not necessary to add yeast to a fermentable liquid to produce fermentation, as by simple exposure to the air a sufficient number of germs will be deposited

in the liquid to begin the process, and the germs will multiply so rapidly that although they may not be many at first, a few hours will suffice to produce them in countless numbers.

The juices of sweet fruits and vegetables, and decoctions made by steeping grains or starchy vegetables in water, undergo fermentation with great readiness. Any solution containing animal or vegetable matter, with sugar, will readily ferment, unless some substance is added to destroy the germs or prevent their activity.

134. **Bread-making.**—The ordinary process of bread-making is an excellent illustration of the process of fermentation. Flour stirred up with water and put into a warm place soon begins to "rise," or ferment. The germs of fermentation contained in the flour and the water, or received from the air, decompose a portion of the sugar into alcohol and carbonic acid gas. The latter bubbles up through the mixture. This occurs within three or four hours after the mixture of flour and water is put into a moderately warm place. If it is desired that the fermentation should take place more quickly, yeast is added. By this means large numbers of active germs are at once introduced into the liquid, and the destructive changes begin immediately.

The alcohol formed in bread is driven off by the heat of the oven in baking, so that no harm is done by it, although in its formation a portion of the sugar which the flour contained has been destroyed, and there have been formed, besides the alcohol, minute quantities of other substances having unpleasant flavors. Hence fermented bread is in some respects inferior to unleavened bread.

135. **Wine-making.**—The manufacturers of alcoholic drinks likewise employ two general methods in

their production. The juices of sweet fruits—as grapes, apples, pears, and cherries—are fermented by the action of germs received from the air or carried upon the surface of the fruit. By this means various kinds of wine, cider, perry, and similar drinks are produced. The amount of alcohol contained in wine or cider depends upon the amount of sugar contained in the fruit. Not infrequently a quantity of sugar is added to the natural fruit juice, so as to produce a large quantity of alcohol. The manufacturer uses great care to stop the fermentation at the right moment; otherwise, as we have already learned, the alcohol would be decomposed into vinegar and water.

In different countries fermented drinks are made from various substances. In some tropical countries palm-wine is made by fermenting the sweet juice of the palm-tree. In Mexico the juice of the cactus is fermented. In Western Asia fermented milk, called koumiss, is as popular a beverage as is beer in Germany or wine in France.

136. **Malt Liquors.**—The manufacture of beer and ale is a more complicated process. The proportion of sugar naturally contained in the grains from which alcohol is commonly made is so small that their use for the manufacture of alcoholic drinks would be unprofitable without some means of increasing it. The grains contain starch in abundance. To convert this into sugar the brewer takes advantage of a natural process, by which sugar is produced from starch for a purpose quite different from that for which he desires it. Nature stores up the starch in grains, as well as in most other seeds, for the purpose of furnishing a supply of food to the little plantlet before it has acquired roots and leaves with

which to gather food from the air and the soil. In the process of germination, or sprouting, this starch is converted into sugar, from which the plantlet forms its first roots and the beginning of the stem.

Taking advantage of this fact, the brewer moistens the rye, barley, or other grain from which he proposes to manufacture alcohol, and then exposes it to a warm atmosphere. As the result, the grain sprouts, just as it would have done had it been planted in the earth. The brewer watches this process carefully until the sprout sent out by each kernel has attained a length which his experience shows him to indicate that the largest possible amount of starch has been converted into sugar. He then dries the grain, and by this means the growth of the sprout is stopped. Then, by soaking the grain with water, the sugar is dissolved out. This process is known as *malting.*

The sweet liquid obtained by the malting of grain is fermented by the addition of yeast. Beer, ale, stout, porter, and other alcoholic drinks manufactured in this way, are called malt liquors. As formerly made, the amount of alcohol contained in these liquors depended upon the amount of sugar or starch furnished by the grain from which they were made. At the present time glucose, a sugar made from corn by a chemical process, is very largely used in the manufacture of malt liquors, so that the amount of alcohol which malt liquors now contain is often very much larger than in those made before the cheap manufacture of glucose was introduced. It is thus evident that the malt liquors now manufactured are more intoxicating than those formerly made.

137. **Distillation.** — The strong liquors — brandy, whiskey, gin, and rum—as well as ordinary alcohol are

made from fermented liquids by a process known as *distillation.* Many substances can be distilled. The process consists in heating the liquid or other substance until it is converted into a vapor, and then condensing the vapor by cooling it until it is reduced to its original state.

A familiar example of distillation may be seen in the boiling of water in a teakettle. The steam which issues from the spout of the teakettle is water in the form of vapor. If by means of a rubber tube this vapor is led into a bottle or other vessel surrounded by ice, it will be cooled and condensed to the liquid form, and will appear as distilled water. By holding a glass filled with ice near the spout of the teakettle, a few drops of distilled water will quickly condense upon the sides of the glass. If the glass is held, instead, to the nose of a teapot containing boiling tea, the liquid which condenses upon the sides of the glass will be found to have the flavor of tea, showing that some portion of the tea was distilled with the water. (See Experiment 4, p. 271.)

It is in a manner precisely similar that alcohol is distilled. A large vessel containing the fermented liquid is heated, and the vapor which rises is conducted through a long coil of copper pipe called a still, which is kept constantly cooled, so that the vapor is condensed. Alcohol readily becomes a vapor at a lower temperature than that at which water boils, and thus, by carefully regulating the heat, the alcohol may be separated from the water. The first time it is distilled, a considerable amount of water passes off with the alcohol; but by repeated distillations the alcohol may be obtained in a nearly pure state. It is by distillation that strong liquors are made. Brandy is the liquor obtained by distilling the fermented juice of grapes and other fruits. Whiskey is

distilled from beer. Gin is generally made by mixing oil of juniper and other substances with alcohol. Rum is made by the distillation of fermented cane-juice with molasses and water. In some countries whiskey is distilled from an alcoholic liquor obtained by fermenting potatoes. Distillation has probably been practised by the Chinese from very ancient times, but was first known among civilized nations about seven hundred years ago.

From what we have learned, it is apparent that although alcohol is made from fruits, grains, and other substances used as food, it is not naturally found in foods, but is the result of processes which change the wholesome elements of the food into a harmful and poisonous substance. It is also evident that the essential difference between the various kinds of alcoholic drinks is merely in the proportion of alcohol which they contain. Thus, brandy, whiskey, gin, and rum are from two fifths to three fifths alcohol; wine, one tenth to one fifth; cider, one twentieth to one tenth; beer and ale, one twenty-fifth to one sixteenth. Small beer contains two or three parts in a hundred of alcohol.

138. **Cider.** — From the above it will be seen that cider, which is by many hardly considered an intoxicating liquor, contains more alcohol than beer, and as much as some kinds of wine. Apple-juice, like the juice of the grape, when first expressed from the fruit, is entirely wholesome; but within a few hours fermentation is set up by the germs which the liquid receives from the air and from the fruit itself. Alcohol is thus formed, the quantity increasing until all the sugar present has been converted into alcohol and carbonic acid gas.

139. **Hard Cider** is a very intoxicating beverage, and produces a very bad form of intoxication. What is

called new or sweet cider often contains a considerable amount of alcohol. If the amount is not sufficient to produce intoxication, it may be sufficient to produce an appetite for alcoholic beverages, which will probably lead to the use of stronger liquors. Many persons have become confirmed drunkards in this way. It is quite difficult to tell the exact moment at which cider changes from a harmless to a dangerous beverage. When the liquid effervesces, as it is certain to do after it is a few hours old, it invariably contains alcohol.

140. **The Alcohol Family.** — There are several other substances besides that commonly known as alcohol, which are known to the chemist by this name. Some of these are formed with ordinary alcohol in the fermentation of malt liquors.

141. **Fusel-oil.** — One of the most poisonous of these substances is fusel-oil. This poison is always present in crude alcohol, and in whiskey and other strong liquors when first distilled; but the greater portion is generally removed by a special process of purification. This is frequently so imperfectly done, however, that more or less of this poison is suffered to remain in the liquor. Fusel-oil is much more poisonous and intoxicating than ordinary alcohol, and whiskey containing it is very deadly in its effects. Large quantities of this sort of liquor are shipped to Africa, where, to the shame of the civilized nations sending it, thousands of the natives are annually destroyed by its use.

Another member of the alcohol family is the liquid commonly known as *wood naphtha.* This is also intoxicating, though somewhat less so than ordinary alcohol. It is sometimes resorted to by persons addicted to drink, when ordinary alcoholic liquors are withheld from them.

The fact that ordinary alcohol is one of a family of substances scientifically known as *alcohols*, all the members of which are both poisonous and intoxicating, is certainly much against its character. If there were no other evidence upon the subject, it could hardly be considered credible that this one member of so bad a family should be a wholesome substance while the others are so very poisonous. Any person who should become addicted to the use of naphtha, or of mixtures containing this substance, would certainly be regarded as quite beside himself; yet it is a fact, well settled by experiment, that naphtha is less intoxicating and less poisonous than the form of alcohol so commonly employed in the various alcoholic drinks.

142. **How Alcohol Behaves.** — Alcohol is a chemical substance, and is capable of combining chemically with various substances, in which respect it differs in a very marked manner from foods. If lighted, alcohol burns like naphtha, kerosene-oil, etc.

Meat and other substances, which naturally decay readily, may be preserved for an indefinite period if placed in alcohol. From this fact alcohol is called an *antiseptic*. Ignorant persons sometimes imagine that because alcohol will preserve a dead body from decay, it may also be useful as a means of preserving life. Nothing could be more erroneous than this reasoning. Many chemical agents are antiseptics—that is, will prevent decay—simply because they destroy the germs by which decay is caused. The same properties which make them destructive to germs, the lowest form of life, make them destructive to human beings, who exhibit life in its highest form.

Alcohol possesses a remarkable affinity for water—so

great that it is very difficult to obtain it wholly free from water. If pure alcohol is exposed to the air, it very rapidly absorbs water from the atmosphere, and so becomes diluted. It also absorbs water from everything with which it comes in contact. It is partly by means of this avidity for water that alcohol works such mischief in the human body. (See Experiment 5, page 272.)

143. **Alcohol a Poison to Plants.** — The active part of a living cell is transparent. A cell to which alcohol has been applied quickly loses its transparency and dies. This is true of both animal and vegetable cells. If the roots of a plant are placed in a vessel containing water, the plant will remain fresh for some time; but if the water contains even a small amount of alcohol, the plant soon dies. Plants, the roots of which were placed in cider or beer, were dead in less than three days.

Professor Darwin made an interesting experiment for the purpose of ascertaining the effect of alcohol upon an insectivorous plant, a variety of *drosera*. The plant was placed under a jar, beneath which was also placed a teaspoonful of alcohol in a watch-glass. In twenty-five minutes the plant was removed, when it showed no signs of life, and the next morning all but one of its leaves were found to be entirely dead.

144. **Alcohol a Poison to Animals.** — We may learn something of the effects of alcohol upon the delicate tissues of an animal by applying it to an egg. (See Experiment 6, page 272.) The egg will look as though it had been boiled. Alcohol produces a similar effect upon muscles, nerves, blood, and every living tissue with which it comes in contact. Pure alcohol is almost as deadly a poison as strychnia or prussic acid. A few ounces of pure alcohol will kill a dog in a very short time. Small

doses prove rapidly fatal to such small animals as leeches and minnows. (See Experiment 7, page 272.) Earthworms wet with alcohol die very quickly. Alcohol is equally fatal to insects. Flies put into a bottle with alcohol are killed by its vapor.

Dr. Percy administered two and one-half ounces of alcohol to a full-grown dog. The animal uttered a loud cry and fell lifeless to the ground. Another physician caused a small dog to be intoxicated daily by a half-ounce of pure alcohol. After a time it became very thin, and at length died in a condition of partial paralysis. A French physician found that fowls died after taking one and one-half teaspoonfuls of brandy daily for a few weeks. A few years ago a newspaper correspondent reported the death of a goat from beer-drinking. Some beer manufacturers had been experimenting upon the animal to test the quality of their beer, which was well shown by the result. It was reported that the parties were arrested under the law prohibiting cruelty to animals, but they were allowed to continue dispensing their beer to human beings.

145. **Alcohol a Poison to Human Beings.** — It would naturally be expected that a substance which is poisonous to plants and to all kinds of animals would be equally poisonous to human beings, whose tissues are composed of essentially the same kind of living substance as those of animals. The results of the experiments made upon animals are constantly confirmed by the experience of thousands of unwise human beings, who are daily experimenting upon themselves. Numerous cases are recorded in which grown persons and children have been killed, sometimes almost instantly, by drinking strong alcoholic liquors.

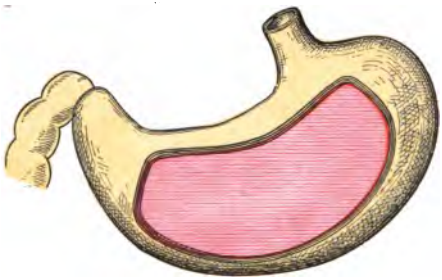
Professor Christison gives an account of a man who stole a bottle of whiskey, and, to avoid detection, drank the whole of it at once. In four hours he was dead. Sir Astley Cooper, the celebrated English surgeon, said, "Spirits and poisons are synonymous terms." Professor Christison and other writers upon poisons mention alcohol among the "narcotic acrid poisons."

The special effects of alcohol upon the heart, lungs, nerves, and other parts of the body, will be described in connection with the study of these organs. Let us now consider the particular effects of alcohol upon the organs and processes of digestion.

146. **Effects of Alcohol upon the Stomach.**—One of the effects of alcohol upon the stomach may be inferred from its effects upon the mucous lining of the mouth. If the liquor is at all strong, the first sensation, when a portion is taken into the mouth, is that of burning and irritation. If retained in the mouth a little time, a sensation of numbness is experienced, showing that the nerves are benumbed or paralyzed. When taken into the stomach, alcohol produces similar effects. The "warming" sensation in the stomach which drinkers enjoy is really an evidence of irritation.

If a cloth is moistened with a little pure alcohol, then laid upon the skin and covered with a piece of oiled silk, the effect produced will be much the same as that of a mustard plaster. The effect of strong alcohol upon the stomach is similar, only the stomach protects itself so far as it can by pouring out mucus to cover its lining membrane. Strong alcoholic drinks paralyze the glands which secrete the gastric juice, and the muscles which contract upon the food.

A hard drinker often has no appetite, and takes no



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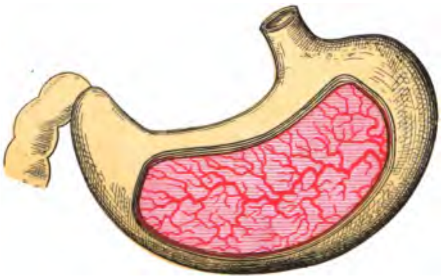

B

EFFECTS OF ALCOHOL UPON THE STOMACH.

A. Healthy Stomach; B. Congested Stomach of a moderate drinker.

PLATE III. 80—A

food for several days. His stomach is paralyzed, so that it cannot digest food. His strength is not kept up by alcohol, however, for he becomes very weak, and his dissipation often ends in an attack of inflammation of the stomach or delirium tremens. These facts show the folly of taking wine or other liquor as an aid to digestion.

147. **Dr. Beaumont's Experiments.** — Dr. Beaumont had a remarkable opportunity for observing the exact effect of alcohol upon the stomach, in the case of Alexis St. Martin, the inside of whose stomach could be examined through an opening. St. Martin sometimes indulged in what is commonly termed a "spree." On one of these occasions, when he had been drinking liquor freely for several days, Dr. Beaumont found the lining of his stomach in a state of inflammation and ulceration, although, strange as it may appear, he complained of no discomfort. Each day the condition grew worse, however, and after a few days he began to suffer some pain and tenderness at the pit of his stomach, dizziness, and dimness of vision on stooping down and rising again. He had a coated tongue, and his countenance was sallow. On looking into his stomach again, Dr. Beaumont found the mucous membrane covered with dark spots, and a large amount of mucus mixed with blood. The discharges from the bowels were like those in dysentery.

The abnormal secretion of mucus temporarily occasioned by alcohol becomes constant when strong liquors are habitually used, and thus catarrh of the stomach is induced—a disease very common among those who use alcoholic drinks.

148. **Alcoholic Dyspepsia.** — Dyspepsia, or indigestion, is almost universal among habitual users of strong alcoholic drinks. This is exactly what would be

expected of an agent which not only irritates and inflames the stomach, but benumbs and paralyzes it, and impairs the activity of the gastric juice. Dr. Roberts, an eminent English physiologist, has shown by experiments that alcohol does not aid digestion, as once thought, but hinders it, even when taken in small quantities. Singularly enough, Dr. Roberts concludes from this fact, not that alcohol is a harmful agent, but that we are in danger of great injury from too active digestion, and that we require alcohol to slow down the digestive process to a safe rate!! This is an excellent illustration of the absurd arguments which even learned men sometimes offer in support of alcohol. Experiments recently made by the author showed that 4 oz. of claret diminished the work of digestion one half, while 2 oz. of brandy nearly suspended it.

B. W. Richardson, M.D., F.R.S., asserts that "as the result of using alcohol there is engendered a permanent disorder, which, for politeness' sake, is called dyspepsia, and for which different remedies are often sought but never found. 'Anti-bilious pills,' whatever the term may mean; 'Seidlitz-powders,' 'effervescing waters,' and all the aids to further indigestion in which the afflicted who nurse their own diseases so liberally and innocently indulge, are tried in vain."

149. **Cancer of the Stomach.**—This horrible and hopeless disease, while not confined to those who use alcoholic liquors, is known to be much more frequent among intemperate persons than among abstainers.

150. **The Gin Liver.**—This is the name applied by physicians to a condition of the liver in which the organ becomes greatly shrunken and covered with little nodules, from which it has been given the name of "hob-

nailed liver," as its surface resembles the sole of an English cartman's shoe filled with hobnails. This form of disease, which renders the liver useless and finally produces death, is a frequent result of the use of strong liquors. *Fatty degeneration of the liver*, in which the liver becomes changed to a mass of fat, sometimes enormously enlarged, is another consequence of indulgence in alcohol. This disease occurs in beer-drinkers as well as in those who use strong liquors.

Examination of the body of a man who has died in a state of intoxication, shows a larger amount of alcohol in the liver than in any other part. This is due to two facts: (1) All the alcohol absorbed from the stomach enters the portal vein, and hence is carried directly to the liver; (2) The liver endeavors to protect the rest of the body from the injurious effects of alcohol, as well as of many other poisonous substances, by absorbing and retaining within itself as much of the poison as possible. It is thus apparent that, next to the stomach, the liver is most exposed to injury from the use of alcohol; and it is anything but marvellous that the beer-drinker and wine-bibber should habitually suffer from inactivity of the liver, "biliousness," and various derangements of this important organ.

151. **Is Alcohol a Food?** — It appears from what we have already learned respecting this drug that there can be little room for the discussion of this question. It is certainly incredible that any substance may be both food and poison at the same time. The essential uses of food are to furnish to the body material for the repair of its tissues, and to maintain the supply of force and heat. Alcohol cannot be assimilated, and hence does not replenish the tissues. When first ad-

ministered, it sometimes occasions an apparent increase of heat, by causing the blood to accumulate at the surface. But, in consequence of this, the body loses heat very fast, so that in a little while it is cooler than before. It has been claimed that as alcohol is oxidized—that is, disappears in the body by combining with oxygen—it must be useful as a means of supplying heat; but the practical fact that the body becomes cooler under the influence of alcohol proves clearly that this drug is of no value as a source of heat, even if some small amount may be oxidized.

Alcohol does not make a person stronger. It acts just as a whip or a spur acts upon a tired horse. No one would venture to assert that a whip really makes a horse stronger, although it makes him appear stronger.

A small amount of alcohol, not more than three or four drachms in twenty-four hours, disappears within the body; but it has by no means been established that the oxidation of alcohol, upon which its claim to value as a food rests, takes place in either the blood or the tissues, or in any manner useful to the body. Dr. Richardson suggests that the alcohol may be largely thrown out in the bile by the liver, and oxidized in the intestinal canal, the products of oxidation being afterwards absorbed. If this theory is established by actual experiments, the vexed question will be forever settled. The great chemist Liebig remarked that the amount of nutriment in a hogshead of the best Bavarian beer is less than that contained in a single loaf of bread,—a statement which will undoubtedly surprise those who have been taught to look upon beer and ale as valuable foods.

The claim has been made that alcohol lessens the wastes of the body, and so economizes food, and is thus

a kind of substitute for food. This claim is disputed by the late Dr. Smith, of England, an eminent authority on foods; but if it be true that alcohol lessens waste, this fact does not establish its claim to the dignity of an article of diet. What we desire of food is *not that it shall diminish waste, but that it shall replace what is lost by work;* for it is only by using up material that the body can manifest force, or that any kind of vital work can be performed. To lessen natural waste is to lessen life. Alcohol deadens and paralyzes, and thus lessens the activity of the nerves and of the little cell-workers with which it comes in contact in the body, and so diminishes vital work.

Careful experiments made by Dr. Parkes, of England, and others, show that the use of alcohol actually lessens muscular strength. Experiments made by Professor N. S. Davis, M.D., of Chicago, and Dr. B. W. Richardson, of London, show very conclusively that alcohol lessens rather than increases animal heat. The temperature of a drunken man is sometimes several degrees less than that of a person in health.

If further argument is needed, we may adduce the fact that alcohol is by no means the only substance that will lessen waste. It is well known that opium possesses this property; and arsenic, one of the most dangerous of poisons, has been shown by the experiments of Schmidt and Sturzwage, two German physiologists, to possess the same properties as alcohol in this particular; yet no one would think of calling either arsenic or opium a food on this account. It is very plain that the argument that alcohol economizes food is brought forward simply as an apology for indulgence in alcoholic beverages, since those who urge it most are not those who

need to avail themselves of its use on the score of economy. Again, the utter folly of this mode of economizing, allowing the claim for alcohol as a food substitute to be established, becomes apparent when we stop to consider the fact that alcohol, in the form of any common drink, costs many times more than the food which it is supposed to save.

152. **The Alcohol Appetite.** — After any narcotic or stimulating drug has been used for some time, the system becomes habituated to it, and an intense desire for the accustomed drug is experienced whenever it is not taken, or when the usual quantity cannot be obtained. This is especially true of alcohol, opium, and tobacco. Another fact of importance is that all drugs of this class create an increasing demand for the particular drug which has been habitually taken, so that it must be taken in increasing quantity. It is in this way that the alcohol appetite, the opium habit, the tobacco habit, and the tea-and-coffee habit are formed.

The use of alcohol, opium, or any other "vice-drug" in small doses will in time produce a demand for large doses. It is in this way that the use of beer, wine, or cider leads to the use of stronger liquors.

153. **Moderate Drinking.** — Many persons argue that the injury done by alcohol is due only to its excessive use. There are two facts which show the great danger of moderate drinking: 1. The use of alcohol in small quantities, often—we may perhaps say usually—leads to its use in larger quantities, in consequence of the formation of the alcohol appetite. After small amounts of alcohol have been used for a time, larger, stronger, or more frequent drinks must be taken to produce the same effects, and thus the moderate drinker

becomes, if not a sot, a hard drinker, taking quantities of alcoholic liquor which at first he would have considered very dangerous. 2. Many of the worst effects of the use of alcohol are to be seen in moderate drinkers. The destructive changes by which the normal structures of the vital organs are so changed as to disable them, thus causing serious and incurable maladies, are frequently found in persons who consider themselves very temperate, and who have never been intoxicated in their lives.

Said the eminent Sir Henry Thompson, a famous London surgeon, "I have no hesitation in attributing a very large proportion of some of the most painful and dangerous maladies which come under my notice, as well as those which every medical man has to treat, to the ordinary daily use of fermented drinks, taken in the quantity which is commonly deemed moderate."

Careful records have been kept for many years by life-insurance companies, both in this country and in England. The statistics derived from these records show that human life is greatly shortened by the habitual use of alcohol, even in what is termed "moderation."

154. "**Bitters.**"—Many persons are unsuspectingly led into habits of intemperance by the use of various kinds of patent medicines advertised as "*bitters*," "*tonics*," etc. Few, if any, of these mixtures are free from alcohol. Some that are said to be free from alcohol, and on that account are called "temperance bitters," actually contain more alcohol than some which make no such claim. Some of the most popular of these nostrums contain as much alcohol as the strongest liquors. "Jamaica ginger" contains so much alcohol that it will burn in a spirit-lamp. The habitual use of these compounds is quite as harmful as the use of alcohol in any

other form, and sometimes even more injurious on account of the presence of other harmful drugs.

155. **Alcohol in Cookery.** — The use of alcohol in cookery is one way in which the appetite for alcohol is cultivated. Sáuces, jellies, preserves, and similar preparations, when they contain wine, brandy, or other alcoholic liquors, have a most pernicious influence, and often lay the foundation for a life of intemperance. Alcohol and kindred drugs are dangerous poisons. They destroy the lives of thousands every year; and even when taken at first in small quantities, they often produce a fatal fascination from which the unfortunate victim never escapes.

156. **Alcoholic Candies.** — Candies and confections of various sorts often contain alcohol in the form of wine or brandy. The use of such candies may readily produce an appetite for alcohol in other and stronger forms. Children have been found in a state of partial intoxication as the result of eating freely of such candies.

The only safe rule for a person who desires to lead a temperate life is to avoid everything which contains alcohol in any form. Any other course is most unsafe; for the alcohol appetite is often formed unconsciously, and is only recognized when it has become fully developed, and has attained the complete mastery.

157. **Absinthe.**—This is an exceedingly poisonous and intoxicating liquor, made by adding the oil of wormwood to alcohol. It has long been very extensively used in France and Switzerland. Recently it has been introduced into this country and England. Absinthe produces the same results as alcohol, with other and even worse effects, due to the poisonous oil which it contains. The stomach and the nerves are especially injured by it.

Its victims are short-lived, and die miserably and with great suffering.

158. **The Origin of Tobacco-using.** — Tobacco-using was first witnessed by Columbus when he discovered America. In his description of his discoveries he stated that he saw "the naked savages twist huge leaves together and smoke like devils." Is it not strange that civilized men should ever have desired to imitate the example of those degraded savages?

Smoking, chewing, and snuff-taking—the principal methods of taking tobacco — all originated with the Indians who inhabited this continent centuries ago; and these practices undoubtedly helped to bring them to the wretched condition in which Columbus and other explorers found them. Civilized man has made no improvement in the practice of tobacco using.

The use of tobacco was recognized as an evil soon after its introduction among civilized nations. Kings issued proclamations and made laws against it. The Pope issued a "bull" against it, and the Sultan of Turkey caused a man convicted of smoking to be led through the streets of Constantinople with his nose slit and the stem of his pipe thrust through it, as a warning to other users of the weed.

Tobacco contains an essential oil, *nicotine*, which is a powerful narcotic and a very deadly poison. A drop of nicotine placed upon a cat's tongue caused immediate insensibility, and death in two minutes. One tenth of a drop killed a frog in a few seconds. A strong cigar contains enough of this poison to kill two men, if taken at a single dose.

The use of tobacco for the destruction of insects in greenhouses is a familiar illustration of its deadly prop-

erties. Professor Darwin has also shown, by experiments upon insectivorous plants, that nicotine is a poison to plants as well as to animals.

The poisonous properties of tobacco are well shown in the effects upon a person not accustomed to its use. The deathly pallor and the extreme nausea and prostration are evidences of its deadly properties. A man once undertook to smuggle a quantity of tobacco by binding it about his body next the skin. He was taken suddenly so ill that his crime was discovered. Cowardly soldiers have been known to make themselves sick upon the eve of a battle by placing tobacco leaves next the skin, under the arms, or over the stomach. Deaths from the use of tobacco are frequently reported in the newspapers, and medical literature records many instances of this sort.

159. **Tobacco Dyspepsia.**—When tobacco is chewed, a part of the poison is absorbed: some is also swallowed. The portion which is swallowed poisons the digestive fluids, so that their work is less perfectly done than it otherwise would be, and hence *dyspepsia* is a very common disorder among tobacco-chewers.

160. **Smoker's Sore Throat.**—The mouth and throat are sure to suffer from the use of tobacco. At first, dryness and unnatural thirst are produced, especially by smoking, and frequently this is the inducement to indulge in alcoholic drinks. After a time, a chronic inflammation is produced, which bears the significant name of "*smoker's sore throat*," a disease with which all physicians are familiar. This disease is absolutely incurable so long as the use of tobacco is continued, and often causes *deafness*, by extension of the disease to the ears.

161. **Tobacco Cancer.**—This dreadful disease usually affects the lips, tongue, or throat. It seldom occurs except in smokers. Women rarely have cancer of the lip, at least in this country. This is because very few women smoke.

Every surgeon of experience has met with cases of cancer of the tongue or lip arising from this cause. It is rare, indeed, that cancer occurs in these parts of the body from any other cause.

Many other grave diseases are due to the use of tobacco; but, besides the harm which it does to the body, it is a gross and uncleanly practice, and often has a most pernicious influence upon the mind and morals. Most tobacco-users show little regard for the feelings of those who do not use the weed, but soil the air which others must breathe, and defile with spittle the floor or pavement over which others must walk, apparently with no thought but for the gratification of their own selfish and unnatural appetite.

162. **Tea and Coffee.**—These popular beverages, generally considered quite harmless, must be included in the list of harmful drinks, although the injury arising from their use is not to be compared with that growing out of the use of alcohol and tobacco. *Tea* consists of the dried leaves of a shrub which grows in China and India. The leaves are picked when young, and dried by artificial heat. *Coffee* consists of the berries of the coffee-tree, a native of Arabia, now cultivated in the East and the West Indies, South America, and other tropical and sub-tropical countries.

Tea and coffee are used chiefly for the mildly stimulating or narcotic effects which they produce. This property is due to a peculiar substance contained in both

tea and coffee, known as *theine* in tea and *caffeine* in coffee. Both tea and coffee also contain tannin and peculiar aromatic substances to which their flavors are due. (See Experiment 8, page 272.)

163. **Harmful Effects of Strong Tea and Coffee.** Theine is a powerful narcotic poison. One seventh of a grain will kill a frog. Five grains will kill a cat. Eight grains administered to a man produced severe poisonous symptoms. Dr. Edward Smith, of England, and his assistant were made insensible by drinking, as an experiment, a quantity of coffee made from two ounces of coffee-beans. Tea contains a very large amount of theine, the proportion being from three to six per cent. An ounce of tea-leaves contains from fifteen to thirty grains of theine, an amount sufficient, if extracted and swallowed at once, to poison a person not accustomed to its use. The *tannin* found in both tea and coffee is also harmful. It injures the stomach, delays digestion, and hinders absorption.

An English officer, while on duty in Africa a few years ago, lost a fine horse by poisoning with tea, a quantity of which was accidentally mixed with the animal's food. The effect of the tea upon the animal was thus described: "The animal plunged and kicked and ran backward, at intervals galloping madly round, finally falling into a donga, where it lay dashing its head on the rocks, and was despatched by an assegai thrust through the heart. The post-mortem appearances indicated extreme cerebral congestion."

164. **Tea-drinker's Dyspepsia.**—An eminent physician stated before the British Medical Association, a few years ago, that in his practice in Australia he had found dyspepsia from the use of tea and coffee exceed-

ingly common. Many English physicians and numerous medical authorities in this country have also observed the same fact. Dr. Roberts, a renowned English physiologist, has shown that digestion is hindered by both tea and coffee.

Tea-drinkers are especially liable to a form of stomach disorder commonly known as sick-headache. Dr. James Frazer, of Scotland, has recently conducted a series of experiments to determine the effects of tea, coffee, and cocoa upon digestion, and finds that the effect of all of them is to retard digestion. Says B. W. Richardson, M.D., F.R.S.: "The extremely injurious effects of tea are best seen in some of those who are charged with the commercial duty of 'tea-tasting.' A professional tea-taster who was so seriously affected by the process that he thought it proper to consult me on the symptoms induced, defined the symptoms very clearly as follows: 'Deficiency of saliva, destruction of taste for food, biliousness, nausea, constipation, an extreme and undefinable nervousness, and nightmare whenever sleep is obtained.'" Says Prof. J. W. Morton, M.D., an eminent specialist in nervous diseases: "I am forced to think that many people, unconsciously to themselves and to their physicians, suffer from a train of symptoms due to tea (or its congener, coffee). We often find people taking tea to relieve the very set of symptoms which its abuse produces; and it is often the fact that patients date their recovery from a dyspepsia or nerve exhaustion from the time when they gave up their tea."

165. **Tea and Coffee not Foods.** — Tea and coffee, as ordinarily used, furnish so little nourishment that they cannot be classed as proper foods. They lessen both the

desire for food and the ability to digest it. They contain no nourishment, aside from the small amount of milk and sugar usually added.

"The cups that cheer, and not inebriate," is an expression often incorrectly used respecting these beverages. Dr. Arlidge, of England, asserts that "tea drunkards" are numerous among the poor women of some parts of that country. In South America, a person who is addicted to the free use of coca-leaves, which also contain theine, is termed a *coquero*, which means the same as the word *drunkard* with us. Two women were arrested for drunkenness in Boston not long since, who proved to be tea drunkards. They had acquired the habit of chewing tea, and had consumed so great a quantity as to produce intoxication.

The Saracens were about the only Eastern nation who did not adopt the use of tea and coffee, as well as alcoholic drinks and other narcotics. A writer in the *International Review* says of this remarkable people: "The Western Saracens abstained not only from wine, but from all fermented and distilled drinks whatsoever, were as innocent of coffee as of tea and tobacco, knew opium only as a soporific medicine, and were inclined to abstemiousness in the use of animal food. Yet six millions of these truest sons of temperance held their own for seven centuries against great odds of heavy-armed Giaours; excelled all Christendom in astronomy, medicine, agriculture, chemistry, and linguistics, as well as in the abstract sciences, and could boast of a whole galaxy of philosophers and inspired poets."

166. **Cocoa and Chocolate.** — These beverages contain a substance similar to theine, known as *theobromine*, the properties of which are essentially the same as

those of theine, though usually present in much smaller amount.

167. **Chloral, Opium, Cocaine, and other Narcotics.**—These substances, with which may be included *hashish*, or *Indian hemp*, and other similar drugs, when habitually used, are the cause of great injury to the digestive organs, as well as to the entire system. Chloral and opium are largely used in this country, as well as elsewhere, and their use seems to be increasing. They are deadly drugs, and their habitual use inevitably leads to physical, mental, and moral ruin.

During many years' experience as superintendent of a large sanitarium and hospital, the writer has met many cases illustrative of the profound mischief wrought by these narcotic drugs, the use of which has given rise to what might be termed the *poison-habit;* for it is rare indeed that a person is found addicted to one only of these narcotic drugs. In such cases, the victim of a poison-habit must give up the use of all narcotics in order to be reformed from the one to which he may be chiefly enslaved.

SUMMARY.

1. All narcotics are poisons. Those in most common use are alcohol, tobacco, opium, tea, and coffee.

2. Alcohol is produced by fermentation. Pure alcohol and strong liquors are made by the *distillation* of fermented liquors.

3. Alcoholic beverages contain from two to sixty per cent. of alcohol.

4. Cider, when "hard," is a very intoxicating liquor.

5. Alcohol is a member of a large family of substances of similar character, poisonous and intoxicating. *Wood naphtha* and *fusel-oil* are alcohols.

6. Alcohol is a poison to plants and animals, as well as to human beings.

7. The effects of alcohol upon the stomach are to benumb its tissues,

impair the gastric juice, cause dyspepsia, inflammation, catarrh, ulceration, and cancer. Four ounces of claret lessened digestion one-half.

8. Alcohol causes hardening and fatty degeneration of the liver.

9. Alcohol does not support assimilation, heat, or force production, and hence is not a food.

10. Alcohol lessens heat and force.

11. The use of alcoholic drinks engenders an artificial craving which nothing else will satisfy, and leads to drunkenness.

12. Many of the worst effects of alcohol may be seen in moderate drinkers.

13. Life-insurance records show that alcohol shortens life, even when used moderately.

14. "*Bitters*" nearly always contain alcohol, sometimes in larger proportion than does rum or whiskey. Their habitual use occasions even worse effects than the use of ordinary liquors.

15. The first tobacco-users were the American Indians.

16. Tobacco contains a deadly poison, *nicotine*.

17. Dyspepsia, sore throat, and cancer of the throat or lip result from tobacco-using.

18. Tea and coffee are not foods: they contain poisonous principles, *theine* and *caffeine*. Their use is a common cause of indigestion.

19. Chloral, opium, and other narcotics, when habitually used, derange the digestive organs, and produce the "poison-habit."

20. Persons who become addicted to the use of one narcotic, are also likely to indulge in others.

CHAPTER XI.

THE BLOOD.

168. We have already learned that one of the essential processes in the nutrition of the body is the *circulation*. It is by means of the circulation that worn-out particles are removed from the tissues and carried to the organs which expel them from the body, while new material is distributed to the tissues, to repair the losses sustained in doing vital work. The medium through which this process is carried on is the *blood*. The blood is a red, opaque, viscid fluid, somewhat heavier than water, and is found in nearly every part of the body. The quantity of blood in the body generally equals about one thirteenth of its weight. Thus, a person weighing one hundred and thirty pounds has about ten pounds of blood.

169. **Composition of the Blood.**—When examined with a microscope (see Experiment 9, page 272) the blood is found to be made up of a clear fluid, the *plasma*, in which are suspended myriads of little bodies termed *blood corpuscles*. (See frontispiece.) The corpuscles constitute about one-half of the entire bulk of the blood. They are so very small that more than a million have been counted in a single drop of blood. The number of corpuscles is diminished by fasting and by loss of sleep.

170. **The Blood Corpuscles.**—A careful microscopic examination of the blood discloses two kinds of

corpuscles, known respectively as *white* and *red* corpuscles. There are three white corpuscles to one thousand red ones. The white cells are spherical in form, and measure about $\frac{1}{2500}$ of an inch in diameter. The white corpuscles are formed by the spleen, the lymph glands, and the bone marrow.

171. **The Red Corpuscles.**—In form, the red corpuscles are very unlike the white, as will be seen by reference to the cut. Their outline is that of a flattened disk $\frac{1}{3500}$ of an inch in its greatest diameter. Each face is hollowed out in the centre, so that the corpuscle is biconcave. The red corpuscles are somewhat smaller than the white ones, and are of a light amber color when seen through the microscope. The red corpuscles are formed by the red marrow of the bones.

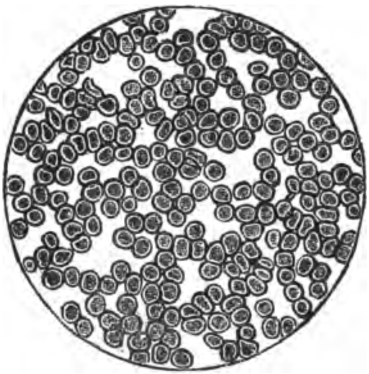

Fig. 14.—Red Blood Corpuscles.

172. **The Plasma.**—The plasma, a clear, colorless fluid, in which the corpuscles float, somewhat resembles the white of an egg diluted so as to be nearly as thin as water. It is chiefly made up of the various constituents of the digested food. In addition to these useful elements, the plasma contains in solution the waste substances which are to be removed from the body by the lungs, kidneys, skin, and other organs of excretion, including the gases, carbonic acid and oxygen. The blood contains something for every tissue: the brain,

nerves, muscles, bones, glands, membranes—all are provided for.

173. **The Spleen.**—This remarkable organ is located at the upper and left side of the abdominal cavity, near the lower border of the ribs. It is of a dark purple color, and is about the size of one's fist. It is believed that its chief use is to make white blood corpuscles, and to destroy red ones.

174. **Uses of the Blood.**—The blood is the medium of exchange between the different parts of the body. It has been aptly called a "circulating market," from which each tissue takes something, and to which each gives something in exchange. Some organs take from the blood more than they give back to it; others give more than they receive. To the nerves, muscles, bones, and other tissues, the blood supplies the elements which they require to make good their losses from vital work, and receives in return the worn-out particles which must be carried away for use elsewhere, or for removal from the body.

In the lungs the blood yields up the carbonic acid gas which it has gathered from the tissues, in exchange for oxygen which it returns to them. The skin, the kidneys, and other eliminative organs, take from the blood water and waste particles, giving nothing in return; but this uneven exchange is compensated for by one of an opposite kind. The walls of the alimentary canal absorb the digested food, and thus bring to the blood a large supply of new material, in exchange for which the blood gives only the comparatively small amount of nutrient substance needed to keep in repair the digestive organs and manufacture the digestive fluids.

175. **The Use of the Red Blood Corpuscles.**—

These wonderful little bodies perform a very important office in the body. They possess the remarkable property of being able to absorb and carry a volume of oxygen or carbonic acid gas much greater than themselves. While exposed to the air in the lungs, each corpuscle takes up a load of oxygen and carries it to the tissues, where the oxygen is given up, and an equal amount of carbonic acid gas is absorbed and carried to the lungs, and exchanged for oxygen. The color of the blood is due to the red blood corpuscles. It is bright red when the corpuscles are loaded with oxygen, but of a darker color when the oxygen has been exchanged for carbonic acid gas.

176. **Use of the White Blood Corpuscles.**—The white blood corpuscles assist in the repair of injuries to the tissues. They are always found in great numbers in a part which is inflamed.

Recent observations seem to show that one of the most important uses of the white blood corpuscles is to destroy germs and other noxious foreign substances which may find their way into the blood. This is perhaps their most important function. In the air we breathe, and in food and drink, we are constantly taking in great numbers of germs. The multiplication of these minute forms of life within the body would result in speedy death were there not some means of destroying them. In health, the white corpuscles constitute a vigilant body-guard, by which these intruders are promptly seized and destroyed, unless they enter the body in such numbers as to overwhelm the corpuscles. If, from any cause, the white corpuscles are so weakened that they cannot perform their duty, the body falls an easy prey to these most dangerous of all enemies to

human life. It is also probable that the corpuscles are useful in liquefying for removal the hard masses often left behind by inflammations. It is, then, of the utmost importance that our blood corpuscles should be preserved in the most perfect health, and that we should avoid the use of any substance which will interfere with their useful work, such as alcohol or tobacco, and other narcotics.

Scientific research has recently brought to light the remarkable fact that the fluid portion, or serum, of the blood also possesses the ability to destroy germs. This power is lost, however, when the blood is rendered impure by gross food, and especially by taking into the system such poisons as tobacco, opium, alcohol, and other narcotic drugs. This is one reason why beer-drinkers frequently die from comparatively slight injuries, and why drunkards are the first victims in cholera and yellow-fever epidemics.

SUMMARY.

1. The circulation of the blood is one of the most essential processes of nutrition.
2. The blood is composed of *plasma* and *red* and *white corpuscles.*
3. Red corpuscles carry oxygen and carbonic acid gas; white corpuscles repair tissues and destroy germs.
4. The blood may be compared to a circulating market.
5. The serum of the blood, when pure, possesses the power to destroy germs. This is lost when the blood becomes impure.

CHAPTER XII.

THE HEART, BLOOD-VESSELS, AND LYMPHATICS.

177. The chief means by which the blood is circulated are the *heart* and a system of closed tubes connected with it—the *blood-vessels*. (See frontispiece.) The latter are of three kinds: the *arteries*, which convey blood from the heart to the tissues; the *veins*, which return blood from the tissues to the heart; and the *capillaries*, very fine vessels which unite the ends of the arteries and the veins.

178. **Structure of the Heart.** — The heart may be described as a hollow muscle. Its size in any individual is that of his own fist. Its shape is conical. It is suspended in the chest, with its base upward, and is placed between the two lungs, which fold around the organ so as nearly to cover it. It is placed about midway between the upper and lower borders of the chest, and a little to the left of the median line. The heart is enclosed in a sac—the *heart-case* or *pericardium*—in which it moves easily, as the surfaces of the sac are kept well lubricated by a limpid, watery secretion. The walls of the heart are composed of muscular fibres, closely interwoven.

179. **The Cavities of the Heart.** — A perpendicular muscular partition divides the heart into a right and a left half, each of which is again divided by a membranous cross-partition into an upper and a lower

portion, making four cavities in all. (See page 104.) The heart may be properly regarded as a double organ, each lateral half being really distinct in function, and having an upper and a lower cavity. The cavities of the heart are lined by a delicate membrane similar to that which lines other closed cavities in the body.

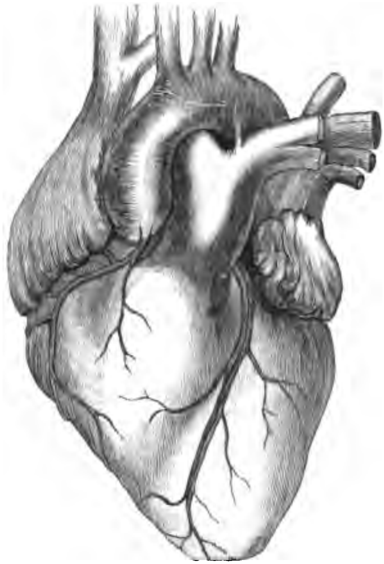

Fig. 15.—THE HEART.

180. **The Auricles.**—The two upper cavities of the heart are known as auricles—right and left respectively. Their walls are comparatively thin, containing but little muscular tissue. Each cavity is capable of holding about six ounces of blood.

181. **The Ventricles.**—The two lower cavities of the heart are called ventricles—the right and the left ventricle. The walls of the ventricles are very much thicker than those of the auricles, and the wall of the left ventricle is much thicker than that of the right. The two cavities are of the same size, and capable of holding about six ounces each.

182. **Openings into the Heart.**—Each ventricle has two openings, one leading to the auricle of the same side, the other connected with an artery. The right

ventricle communicates with the *pulmonary artery*, which goes to the lungs; the left, with the *aorta*, the largest artery of the body.

The right auricle presents two openings in its outer wall, through which it receives blood from the two largest veins in the body, the *ascending* and the *descending vena cava.* The left auricle has four openings, which receive the blood from the four *pulmonary veins*, two from each lung.

183. **The Valves of the Heart.** — The two openings of each ventricle are guarded by valves, which permit the blood to pass in but one direction. The valve between the right auricle and the right ventricle consists of three delicate membranous curtains. One side of each curtain is attached to the edge of the opening, while the other is attached by tendinous cords to the walls of the ventricle. The valve between the left auricle and the left ventricle has two such curtains. As the ventricles fill with blood, these curtains float up until they completely close the openings between the ventricles and the auricles. The valve of the right side is known as the *tricuspid valve;* that of the left side, as the *bicuspid* or *mitral valve.* The opening from the left ventricle into the aorta, and that of the right ventricle into the pulmonary artery, are guarded by the aortic and pulmonary valves, exactly

Fig. 16.—Inside of Heart.

alike, and known as the *semilunar valves.* These valves allow the blood to pass from the auricles to the ventricles, and from the ventricles into the arteries, but not in the opposite direction.

184. **The Arteries.** — All vessels which convey blood from the heart are called *arteries.* The largest artery of the body, the *aorta,* leaves the heart at the left ventricle, and soon begins to send off branches to various parts. These branches subdivide many times, until they become exceedingly minute, quite too small to be seen by the naked eye.

185. **The Capillaries.** — The smallest divisions of the arteries terminate in a net-work of very small vessels, which are termed capillaries. An idea of the relation of the arteries to the capillaries may be obtained by observing the veins of a net-veined leaf. It will be noticed that the veins of the leaf continually subdivide until they end in a delicate net-work which resembles the finest lace. This is well shown in a "skeleton leaf."

186. **The Veins.** — The capillary vessels are very short. They soon begin to gather into larger and larger trunks, thus forming the veins. The veins unite as they approach the heart, forming larger and larger trunks, until at last two large veins are formed, one coming from the upper part of the body, the other from the lower part, known respectively as the *descending vena cava* and the *ascending vena cava.*

187. **Structure of the Blood-vessels.** —The large arteries have firm, elastic walls, which retain their form whether full or empty. The walls of the arteries are made up of three layers: a *lining* of membrane, a *covering* of connective tissue, and a *middle layer* of muscular tissue.

In the smallest arteries, the outer layer becomes very thin, and the muscular layer much thicker. In the capillaries the muscular coat is lost, the walls consisting of membrane only, and being so thin as to be transparent. The smallest capillaries are hardly so large in diameter as the red corpuscles. The veins have thinner and less rigid walls than the arteries, with very thin muscular fibres. In many parts of the body they are furnished with *valves*, which are not found in the arteries. The valves of the veins act in such a manner as to allow the blood to pass in but one direction, towards the heart.

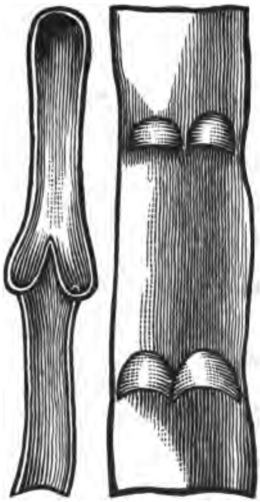

Fig. 17.—Valves of Veins.

188. **Capacity of the Blood-vessels.**—The blood-vessels are capable of holding much more blood than they are ever required to contain. The veins have a capacity more than double that of the arteries, and sufficient to contain all the blood of the body.

189. **The Systemic Circulation.**—When the blood leaves the left ventricle it is distributed through the arteries to the capillaries in all parts of the body, whence it is gathered up by the veins and brought back to the heart. The blood sent out by the left ventricle reaches the heart again at the right auricle, from which it enters the right ventricle. This course of the blood from the left ventricle to the right ventricle is known as *the systemic circulation.* (See frontispiece.)

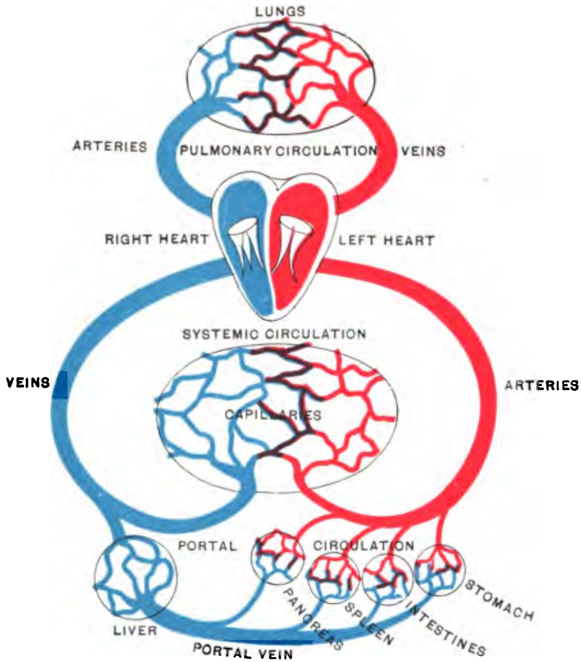

DIAGRAM OF THE CIRCULATORY SYSTEMS.

106—A. PLATE IV.

190. **The Pulmonary Circulation.**—The blood which is sent out by the right ventricle is carried by the *pulmonary artery* to the lungs, whence it is collected and carried to the left auricle by the four *pulmonary veins.* From the left auricle the blood passes to the left ventricle. This course of the blood from the right ventricle through the lungs to the left ventricle is known as the *pulmonary circulation.*

191. **The Portal Circulation.**—Some of the blood which leaves the left ventricle in its course through the systemic circulation does not return directly from the capillaries to the heart. That portion which is distributed to the stomach, spleen, pancreas, and intestines is gathered up into a single large vein, the *portal vein*, by which it is taken to the liver, where it is again spread out in a capillary system. This blood is distributed in the capillaries of the liver, and at length finds its way back to the systemic circulation through the *hepatic vein*, thus passing through two sets of capillaries in its course from the left to the right side of the heart. This is known as the *portal circulation.* (See Plate I.)

192. **The Lymphatic System.**—Closely connected with those portions of the circulatory apparatus already described is the *lymphatic system*, which comprises the *lymph-vessels*, or *lymphatics*, the *lymphatic glands*, and a circulating fluid, the *lymph.*

193. **The Lymph-vessels.**—Outside the blood-vessels in the interlacing net-work of the tissues are numerous irregular spaces filled with fluid. Connected with these spaces are minute tubes, the lymphatics, or lymph-vessels, which form an intricate net-work throughout the body, all converging towards the centre of the trunk, where they unite to form two large vessels, or ducts,

which join the venous circulation near the heart. One which passes upward along the back side of the abdomen and joins the large vein from the left arm, is known as the *thoracic duct*, which, as we have elsewhere learned, carries some portion of the digested food as well as lymph. The *lacteals* is the name given to the lymph-vessels of the intestines. The lymph-vessels are abundantly supplied with valves, which allow the lymph to flow only in the direction of the heart.

Fig. 18.
LYMPHATIC VESSEL.

194. **The Lymphatic Glands.**—Scattered here and there throughout the body are found roundish masses of varying size, through which the lymph-channels pass in their progress towards the heart. These are called *lymphatic glands*. The largest collections of lymphatic glands are found in the neck, the axilla, and the groins. Large numbers of these glands are placed along the intestinal canal, being here termed the *mesenteric glands*.

195. **The Lymph.**—The spaces in the tissues and the lymphatic vessels connected with them contain a clear, colorless fluid, the *lymph*, which closely resembles the blood, only it is not red in color, and contains great numbers of white blood corpuscles, with but few red ones. The lymph is chiefly derived from the capillaries and minute blood-vessels, the thin walls of which allow the plasma to soak through into the tissue spaces. Many of the white blood corpuscles, with a few red ones, also manage to escape through the capillary walls into the tissue spaces.

The lymph receives nutritive elements,—digested food,

water, and oxygen from the blood,—and conveys them to the tissues. These, in turn, give up to the lymph their waste elements, which are passed from the lymph to the blood. The lymph thus forms a medium of exchange between the blood and the tissues.

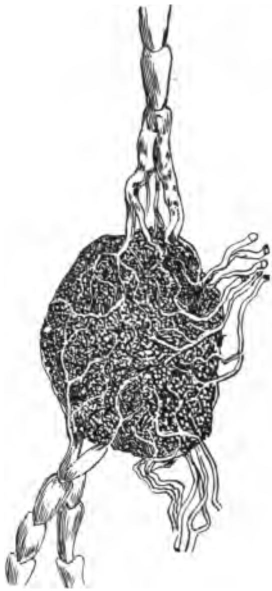

Fig. 19.
LYMPH-GLAND AND VESSELS.

It is thus readily seen that the lymphatic system is an important part of the general circulatory system. It not only serves as a medium of exchange between the blood and the tissues, but returns to the heart those portions of the blood which escape from the blood-vessels into the tissues, and drains the tissues of superfluous fluid, waste matters, and worn-out elements.

The lymph-vessels also drain serous cavities, such as joints, the heart-case, and the cavity of the chest, beginning in these structures by means of small openings in the lining membrane.

The lymphatic glands contain cells resembling the white blood corpuscles, which multiply by division, thus adding to the number of white corpuscles in the body. It is a curious fact that the older white blood corpuscles are broken up and disappear in the lymph-glands, their remains being taken up by the newly formed white corpuscles just as are germs and other foreign particles which sometimes enter the blood.

SUMMARY.

1. The heart and the blood-vessels are the chief means by which the blood is circulated.

2. The heart is a hollow, muscular organ, really a double organ, each half having two cavities—*auricle* and *ventricle*—and two sets of *valves*.

3. *Arteries* convey blood from the heart: *veins* convey blood to the heart; *capillaries* connect arteries and veins.

4. The arteries and the veins have three coats—outer, inner, and middle. The middle coat is muscular. The capillaries have only the lining coat. The veins have valves.

5. There are three circulatory systems: Left side of heart to right side—*systemic;* right side to left—*pulmonary;* from stomach, intestines, pancreas, and spleen, through the liver—*portal*.

6. In the general circulation there are two sets of vessels which return blood to the heart, viz., the veins and the *lymph-vessels*.

7. The lymph-vessels collect from spaces in the tissues the clear fluid, the *lymph*, which they empty into the large veins near the heart.

8. The lymph is chiefly made up of white blood corpuscles and blood plasma.

9. The lymph-vessels are connected with the *lymphatic glands*.

10. The lymph forms a medium of exchange between the blood and the tissues, returns to the blood escaped corpuscles and plasma, and removes from the tissues surplus fluid and waste and worn-out elements.

11. The lymph-vessels and glands connected with the intestines are called lacteals and mesenteric glands.

12. The lymphatic glands destroy old white-blood corpuscles, and form new ones.

CHAPTER XIII.

HOW THE BLOOD IS CIRCULATED.

196. The circulatory system of the body comprises the heart, blood, blood-vessels, lymph, lymph-vessels, and lymphatic glands. The heart is the great centre of the circulatory apparatus. It may be called a self-operating force-pump, which, alternately filling and emptying itself, keeps up the circulation of the blood throughout the body, from earliest infancy to the latest moment of life.

197. **The Heart-beat.**—If the hand is placed just over the fifth and sixth ribs, a little to the left of the breastbone, an impulse will be felt with each beat of the heart. After each impulse will be observed a short pause, lasting about as long as the beat. This fact accounts for the ability of the heart to work so incessantly. It takes a short rest after each beat.

198. **Work Done by the Heart.**—The amount of work done by the heart during life, or even during a single day, is immense. At each beat the ventricles lift into the arteries about twelve ounces of blood. In less than half a minute, at the usual rate of beating, an amount of blood passes through the heart which is equal to the entire quantity of blood in the body. In twenty-four hours the blood pumped by the heart amounts to the enormous quantity of more than three hundred barrels. The force required to circulate this amount of blood is estimated to be not less than that which would

be used in lifting one hundred tons one foot high in a minute.

199. **The Heart-sounds.** — By placing the ear to the chest of another person, one may hear at the moment of the heart-beat a peculiar sound. By giving very careful attention, two sounds may be heard. The sounds of the heart are chiefly caused by the closure of its valves.

200. **Heart Regulators.** — The heart is supplied with two very important nerves which regulate its action. One of these nerves causes the heart to go faster, when greater activity is required, and the other causes it to beat slower, when it tends to go too fast. Thus, by the combined action of these two nerves, the heart's action is regulated to a nicety.

201. **The Pulse.** — In the arteries the blood travels in waves or jets. At some points large arteries come near to the surface of the body, and if the finger is placed upon one of these points an impulse can be felt at each beat of the heart, which is called the *pulse*. We usually feel the pulse at the wrist; but it may be felt at the neck and many other places. If we count the pulse of a child, we find it beating at the rate of eighty to one hundred a minute. In grown persons, the rate is sixty to seventy beats a minute. The pulse-rate changes also with exercise and change of position. A record of the pulse may be made by means of an ingenious instrument called a *sphygmograph*, or pulse-writer. The record made by a healthy person is shown on page 121, where it is compared with the record made by the pulse of a drunkard and by that of a tobacco-user. By the use of this instrument it is easy to tell whether a person has a weak or a strong heart. (See Experiment 10, page 273.)

202. **The Capillary Circulation.** — By the aid of a good microscope the circulation of the blood may be easily studied in the thin web of a frog's foot. (See frontispiece.) The red corpuscles may be seen filing slowly through the narrow capillaries, sometimes singly, often in ranks of two or three, until they reach the smallest capillaries, through which they pass in single file. A minute inspection shows here and there a white corpuscle, apparently clinging to the wall of the blood-vessel, or dragging itself slowly along in the direction of the current. Occasionally one will be found which is making its way in some mysterious manner through the vessel wall. After performing in the tissues some duty too subtle for the eye to follow, the white corpuscle which has escaped starts off on its journey back to the heart by the roundabout road of the lymph-vessels.

It is in the capillary circulation that the exchanges between the blood and the tissues take place.

203. **The Circulation in the Veins and the Lymph-vessels.**—The blood flows onward in the veins in a steady stream. The valves with which the veins are provided prevent any backward movement of the blood, and the pressure from behind constantly urges it forward. The expansion of the chest with each act of inspiration produces a suction force which empties the large veins near the heart. The ventricles of the heart act slightly in the same manner, as they expand after each contraction. This suction action of the heart and the chest, especially of the latter, assists the lymphatic circulation as well as the movement of the blood in the veins. The action of the chest is also especially useful in aiding the portal circulation.

204. **Venous and Arterial Blood.**—The blood which circulates in the arteries of the systemic circulation, called *arterial blood*, is bright red in color. During its passage through the capillaries of the systemic circulation the blood, as we have already seen, gives up its oxygen in exchange for carbonic acid gas, which occasions a change in color from bright red to dark purple. It is now known as *venous blood*, and must be distributed to the various eliminative organs for purification. The pulmonary arteries, receiving their blood from the right side of the heart, contain venous blood; while the pulmonary veins, receiving the blood after it has passed through the lungs, contain arterial blood.

205. **Regulation of the Blood Supply.**—The general supply of blood to the body is regulated by the action of the heart. When more blood is needed by the tissues in general, as in active exercise, the heart works faster; and when less is required, as during rest or sleep, its rate is diminished. Each part of the body requires, in addition, some special means for regulating its blood supply. This special regulation is secured through nerves connected with the muscular coats of the arteries. (See Experiments 11, 12, pages 273, 274.) When more blood is needed in a certain organ or part, the muscular coats of the small vessels are, through the influence of certain nerves, caused to relax, so that the blood passes through more rapidly, and a larger supply is thus obtained. When less blood is wanted, the vessels are made to contract, and thus the amount of blood received is diminished. *Blushing* is due to a sudden relaxation of the vessels of the face under the influence of certain mental emotions. The same effect is produced by alcohol and some other drugs. Blanching of the

face, or pallor, results from sudden contractions of the small vessels, the effect of fear, rage, or distress.

The heart seems to be constantly active, but this is not really the case. As a matter of fact, the heart occupies nearly as much time in resting as in working. Each contraction occupies nearly half a second, and each beat is followed by a complete rest of about half a second. It is this constant stopping to rest that enables the heart to work on during a long life, apparently without stopping to rest.

SUMMARY.

1. The circulatory apparatus comprises the heart, blood, blood-vessels, lymph, lymph-vessels, lymphatic glands.

2. The *pulse* is the impulse felt in an artery. The average pulse-rate is sixty to seventy per minute, varying with age, position of body, and exercise.

3. The blood moves in the arteries with irregular impulses; in the veins, in a slow, steady stream; in the capillaries the movement is almost imperceptible.

4. The general and local supply of blood is regulated by the action of the nervous system upon the heart and the muscular walls of the small arteries.

5. The heart rests between its beats.

CHAPTER XIV.

HYGIENE OF THE HEART, BLOOD, AND BLOOD-VESSELS.

206. The heart is one of the most essential of all the vital organs. Its sudden failure causes instant death, and yet it may go on beating regularly seventy or more times a minute, without once missing a beat, for three or four score years, or even for a century. Nature has provided the most ample and efficient means for adapting its action to all the ordinary conditions and emergencies of life; and if we take care to impose upon it no needless burdens, and to subject it to no ill-treatment, we may expect it to do its duty well for a long lifetime. If it fails to do this, the cause is usually some indiscretion for which we are ourselves responsible.

207. **Effects of Exercise upon the Heart.**—When a person walks rapidly, or runs, or engages in any form of active exercise, the heart beats faster just in proportion to the degree of activity. Every one has experienced the heavy and rapid beating of the heart which is excited by violent exertion, as from running until out of breath. The heart is a muscle, and whatever calls into action the other muscles of the body causes the heart to make extra exertion also.

If a person's habits are sedentary,—in other words, if he does not accustom himself to daily and active exercise,—the heart, as well as the other muscles of the body,

becomes weak. If such a person hurries to catch a train, or runs up a flight of stairs, he gets out of breath very easily, and perhaps suffers from a heavy beating or palpitation of the heart. Sufficient daily exercise should be taken to keep the heart strong and vigorous, so that it will not be unpleasantly affected by moderate exertion. A person whose heart has been well strengthened by systematic muscular exercise can walk rapidly for hours without inconvenience.

Proper exercise also secures good distribution of the blood, a quickening of the assimilation in all parts of the body, and a more prompt and thorough removal of the waste elements. Violent exercise should be avoided by a person who has not by daily and carefully graduated practice become accustomed to it.

208. **Effects of Heat and Cold.**—Heat stimulates the heart's action to a high degree. The effect of cold is to depress and paralyze the action of the heart and small blood-vessels; hence the importance of protecting the body from extremes of heat and cold, by carefully adapting the clothing to the season and the circumstances. It is particularly important to clothe well the extremities, so that a proper balance of the circulation may be maintained.

The clothing must not obstruct the circulation. Many of the largest veins, particularly those of the extremities, are located near the surface, so that any constriction is certain to interrupt the flow of blood through them. Tight shoes or boots, elastics for the arms or legs, and constrictions about the waist or neck, are all very injurious.

209. **Sleep and the Blood.**—Every one has noticed that loss of sleep causes a person to look pale. During

sleep the red corpuscles which are worn out during the day are replaced, and thus the red color of the blood is maintained. If one does not sleep, this repair of the blood does not take place so perfectly, and the blood becomes thin and pale. Pallor is also due in part to the exhaustion of the nervous system.

210. **Mental Influences.** — Violent emotions of every description affect the heart injuriously. Many a man has dropped dead under the excitement of rage, through sudden failure of the heart. The receipt of joyful news has sometimes occasioned so great excitement of the emotions as to cause death by overtaxing the heart. The lesson to be learned from these facts is that the emotions and passions should be kept well under control. A violent fit of anger is really as dangerous as exposure to small-pox or cholera.

211. **Food and Blood.** — The blood is made of what we eat. Poor food makes poor blood, which in turn makes poor tissues, and hence a poor body. An insufficiency of food very soon makes the blood poor and thin. Exciting, irritating, or stimulating foods injure the quality of the blood, and thus cause every tissue in the body to suffer. Condiments, such as pepper, pepper-sauce, mustard, and other hot and irritating substances, are to be condemned on this ground. Excess in the use of fats and highly seasoned foods renders the blood gross and impure.

212. **Effects of Alcohol upon the Blood.** — A drop of alcohol added to a drop of blood almost instantly destroys the blood corpuscles. Prof. William Carpenter, M.D., the eminent English scientist, asserts that one part of alcohol in five hundred parts of blood will injure the blood and the tissues. This proportion of

alcohol is furnished by a large quantity of any strong liquor, or a large quantity of wine, beer, or cider. When alcohol is taken freely, the blood loses in part its power to carry oxygen. This accounts for the bluish appearance of the face, nose, and lips of a hard drinker. Alcohol, even in small quantities, coagulates the fibrine of the blood, producing fine clots, which obstruct the capillaries, causing degeneration of tissues, and thus laying the foundation for incurable diseases.

As we have learned, one of the most important uses of the white blood corpuscles is to destroy germs and to repair the tissues. Alcohol paralyzes these delicate elements of the blood so that they cannot do their work properly. A man under the influence of alcohol is precisely in the condition of a city whose guard of soldiers has been put to sleep by some powerful drug; the enemy enters without resistance. It is for this reason, no doubt, that drunkards are so susceptible to various germ diseases. Persons addicted to the use of alcohol are usually the first victims to cholera and yellow-fever. This is doubtless one reason, also, why intemperate persons do not recover from accidents or surgical operations as readily as do total abstainers.

213. **Alcohol and Fatty Degeneration.**—It is also found that the habitual use of alcohol increases the amount of fat in the blood, causing in various organs the change known as *fatty degeneration*, in which portions of the brain, liver, heart, kidneys, and other organs are changed to fat. When this change has occurred in an important vital organ death is a certain result, as the condition is incurable.

214. **Effects of Alcohol upon the Heart and the Blood-vessels.** — Alcohol quickens the pulse, not by

giving strength to the heart, but by paralyzing the nerve centres which control the heart and the small blood-vessels. Benumbed by alcohol, these nerve centres lose their control over the muscular walls of the small arteries, allowing them to relax; the blood is thus allowed to flow through them more easily, a share of the resistance which the heart is accustomed to overcome having been removed. In consequence, the heart "runs away," as it were, like a steam-engine which has lost its "governor," or a clock pendulum from which the weight has been removed.

215. **Alcohol and Animal Heat.** — The larger amount of blood circulating in the small arteries of the surface of the body, when alcohol has been taken, produces a sensation of increased warmth; but the blood cools off so much more rapidly at the surface than in the interior of the body, that the general temperature quickly falls. The small amount of heat possibly produced by alcohol is not sufficient to make good this extra loss. It is thus evident that alcohol is of no value to the body as a source of heat. All the survivors of the ill-fated Greely expedition were total abstainers.

216. **Alcoholic Disease of the Heart and the Blood-vessels.** — A heart which has been thus abused by alcohol, after a time becomes weak and irregular in its action, as is well shown by the sphygmographic tracing of a drunkard's pulse, given on the next page. Compare this with the tracing of the pulse of a healthy person, shown on the same page.

The long-continued use of alcohol in large quantities produces organic or structural changes in the heart. It sometimes becomes overloaded with fat. In other cases its muscular tissue is changed to fat and loses its strength,

so that the heart-beat is a mere flutter. The muscular walls of the small arteries of the brain and other parts undergo a similar change, and finally become so weak that they are unable to resist the pressure of the blood. A rupture occurs, and the patient dies of apoplexy.

Several years ago some very interesting experiments were made in England by the celebrated Dr. Parkes, F.R.S., who had in charge the sanitary department of the British army. Dr. Parkes gave alcohol to a soldier, and then observed his pulse. He found that one ounce of alcohol a day increased the heart-beats very perceptibly, and that eight ounces, equivalent to a pint of whiskey, compelled the heart to beat one-fourth more times than when water only was used. In view of these facts, it is not surprising that those who use alcohol are so liable to disease of this important organ.

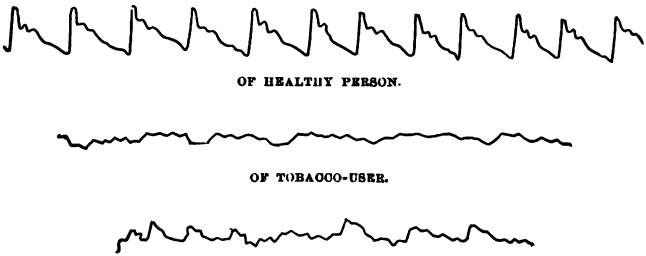

Fig. 20.—Sphygmographic Tracings of the Pulse.

217. **Effects of Tobacco upon the Heart and the Blood.**—The pulse of the tobacco-user indicates unmistakably the injury which this drug works upon the heart. It has lost the firm, steady beat of health, and is feeble and irregular. The sphygmograph

shows this very plainly. This condition is now so well known that it has received the name "*tobacco heart*," and is so called by physicians. Those who have made a careful study of this subject claim that not less than one in every four users of tobacco have this kind of heart. The examining surgeons of the United States army state that a large share of the young men who are rejected are found to be suffering from tobacco heart.

B. W. Richardson, M.D., F.R.S., has made many examinations of the blood of tobacco-users, and states that the effect of smoking is to make the blood thin, and to cause the corpuscles to lose their round form and the ability to adhere together, which are signs of good health.

Some users of tobacco may say: "If these facts are true, why do not all tobacco-users die from the use of the weed?" The answer to this is that the system has a wonderful power of adaptation; so great, indeed, that one may accustom himself to the use of almost any poison until he can take it in enormous doses, and apparently without suffering immediate injury, although destructive changes which will ultimately result in death may be slowly taking place all the time. If it were not for this fact, many tobacco-users would not live twenty-four hours. It is doubtless the case, nevertheless, that most persons who habitually use tobacco actually die of its use, since their lives are shortened, or their systems prepared for the ready reception of some disease which carries them off prematurely.

No boy or young man can afford to acquire the practice of using this filthy weed. Its effects upon adults are bad enough, but upon boys and young men its influence is even worse.

218. **Tea and Coffee.** — Palpitation, or heavy beating or thumping of the heart, is an unpleasant symptom with which almost every one is familiar. Those who are addicted to the use of strong tea and coffee often suffer from this annoying affection. These beverages are very unwholesome, especially for young persons, and may be well replaced by so wholesome and palatable an article as hot milk.

219. **Fainting.**—When the heart beats so feebly that an insufficient quantity of blood is sent to the brain, the person becomes unconscious, or faints. A fainting person should be placed at once in a horizontal position, or with the head lower than the rest of the body. A little cold water should be dashed in the face or on the chest, and the limbs should be briskly rubbed. Hot water applied to the top or back of the head, or over the heart, is more effective than cold water. If a person faints in a close or crowded room he should be carried at once to the open air, or to a room where an abundance of fresh air can be secured. If nothing is done, the heart's action may cease entirely and death may occur. A fainting person is always pale. If the face is red, the case is probably one of apoplexy, and the head should be held high instead of being lowered. Cold water should be applied freely to the head and the neck, and a physician should be called at once. If the insensibility is caused by intoxication, the breath will smell of alcohol.

220. **Taking Cold.**—Most colds are contracted by wetting the feet, getting chilled, cooling off suddenly when perspiring freely, or in some other way disturbing the surface circulation. The consequence is congestion of some internal organ, especially of the lungs, the throat,

or the nasal cavity. When one has been exposed to the causes of cold, the balance of the circulation should be restored as speedily as possible. If one's clothing has been accidentally wet, and the wet garments cannot be exchanged at once for dry ones, he should be warmly wrapped up in dry blankets, or should exercise actively to keep up a good circulation, and thus prevent chilling.

221. **Hemorrhage.** — In attempting to check severe bleeding from a cut or other wound, it should be remembered that the blood in an *artery* is flowing *from* the heart, while that in a *vein* is flowing *towards* the heart. Hence, in case the bleeding is from an artery, the compression by means of the thumb, the fingers, or a bandage should be applied on the side towards the heart. In case of bleeding from a vein, it should be applied on the opposite side of the wound. In many cases it is necessary to apply the compression upon both sides of the wound, as both arteries and veins may be wounded. Bleeding from an artery may at once be detected by the bright red color of the blood, and by its flowing in jets; while from veins it comes in a steady stream, and is of a dark red color.

If the hemorrhage is from a vein, elevate the limb at once. This will control a mild hemorrhage in many cases. If the bleeding continues, tie a marble or a large pebble in a handkerchief, and placing the knot upon the limb just above the wound, tie the handkerchief rather loosely around the limb. Slip a short stout stick through the loop, and twist it until the firm compression controls the bleeding. Care should be taken not to make more pressure than is really necessary, and the bandage must not be kept in position so long as to injure the parts by pressure. Elevation of the arms above the head,

and bathing the face with hot water, are excellent means of checking *nosebleed*. Call a physician at once if the bleeding is severe and does not cease quickly.

SUMMARY.

1. Proper exercise increases the strength of the heart. Violent exercise is injurious, and may prove fatal to a person of sedentary habits.
2. Heat stimulates the heart and the blood-vessels. Cold depresses and paralyzes. Hence the need of suitable clothing.
3. Violent emotions affect the heart profoundly.
4. The quality of the blood is directly dependent on the character of the food.
5. Strong alcohol destroys blood corpuscles instantly. In the body alcohol paralyzes the blood corpuscles so that the red corpuscles cannot carry oxygen, and the white cannot destroy germs nor repair the tissues.
6. Alcohol tends to and often causes fatty degeneration of the heart and other organs.
7. Alcohol paralyzes the heart and the blood-vessels, and causes loss of animal heat.
8. Tobacco often causes a diseased condition known as "tobacco heart."
9. The use of strong tea and coffee causes palpitation of the heart.
10. Fainting is due to a sudden failure of the heart.
11. Stop hemorrhage by compressing the wound and elevating the wounded part.

CHAPTER XV.

THE ORGANS OF RESPIRATION.

222. ALL living things breathe. Plants breathe by means of their bark and leaves. The smallest insect is as dependent upon the "breath of life" for its existence as is a horse or a man. Even the smallest living cell breathes. The earthworm breathes with its slime-covered skin, as it slowly wedges its way through the moist earth. In man and all higher animals a complicated mechanism is required to carry on this important vital process. The organs of respiration are the *air-passages* and the *lungs*, and the *thorax*, or *chest*, with its ribs and muscles.

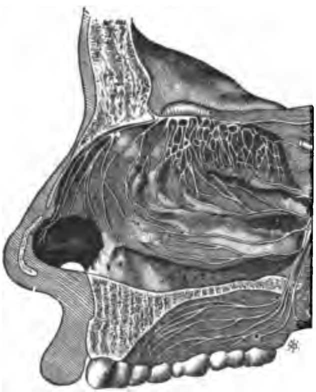

Fig. 21.—THE UPPER AIR-PASSAGES.

223. **The Air-passages.**—The passages which lead to the lungs begin with the *mouth* and the *nostrils*. The nostrils communicate with the cavity of the nose, or *nasal cavity*. Beginning at the nostrils, and extending about one half its length, the nasal cavity is divided into two compartments by a partition termed the *septum*. The sides of the nasal cavity are covered with mucous membrane, the extent of which is greatly in-

creased by scroll-like projections of bone and cartilage from the outer walls of the cavity.

224. **The Pharynx.** — The nasal cavity and the cavity of the mouth unite at their back parts to form the *pharynx*, which is separated from the mouth by a pendulous partition—the *soft palate*—from the centre of which hangs the *uvula*. This membranous curtain may be drawn up so as to close the opening between the pharynx and the nasal cavity. When drawn forward it may be made to meet the tongue in such a manner as to separate the mouth from the pharynx.

On either side of the pharynx are placed the tonsils, two glands which help form the saliva, and which are very apt to become acutely inflamed and permanently enlarged. Out of sight, behind the soft palate, on the back walls of the pharynx, is another gland known as the *pharyngeal tonsil*, which sometimes becomes enlarged and obstructs the breathing.

225. **The Larynx.** — Beginning at the pharnyx is a cartilaginous tube leading to the lungs, the upper part of which is known as the *larynx*. This organ may be roughly described as a cartilaginous box containing the essential organs of the voice, the *vocal cords*, of which we shall learn more elsewhere.

The upper part of the larynx is guarded by a closely fitting cover, the *epiglottis*, consisting of a leaf-shaped cartilage, one side of which is hinged at the root of the tongue in such a manner that when the tongue is drawn back, in the act of swallowing, the cover is tightly closed, preventing the entrance of food or drink into the larynx.

226. **The Trachea.** —From the larynx the tube extends down into the chest. Here it is known as the *windpipe*, or *trachea*, which is made up of incomplete

rings of cartilage, joined together by membranes and other structures in such a way as to leave the back side of the tube closed only by soft tissues—an important provision, as the gullet, or meat-pipe, lies just behind the trachea.

227. **The Bronchial Tubes.**—In the upper part of the chest the trachea divides into two branches, the

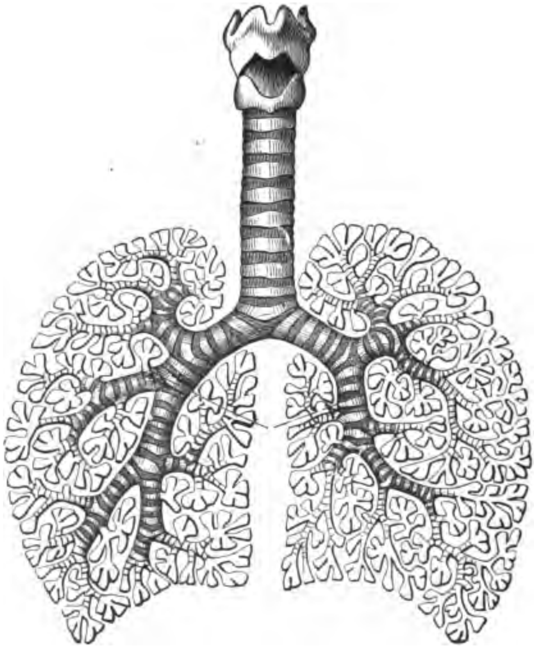

Fig. 22.—AIR-TUBES AND AIR-CELLS.

bronchial tubes, one of which passes off to the right side, the other to the left. These branches divide and subdivide like the branches of a tree, to which the trachea

and its branches may be not inaptly compared, viewing the tree inverted.

The smallest tubes are exceedingly minute. The large tubes, like the trachea, have a framework of cartilaginous rings, which is covered and lined by membranes. In the smaller tubes the cartilage rings become less distinct, and in the smallest are lost altogether. The walls of the small tubes are chiefly made up of mucous membrane and muscular tissue.

228. **The Air-cells.**—At the end of each of the smallest air-tubes is a small sac called a *lobule*, which, by the infolding of its walls, is divided into numerous cells, each lobule having fifteen or twenty such subdivisions. The total number of these air-cells in the lungs is estimated to be not less than 1,700,000,000.

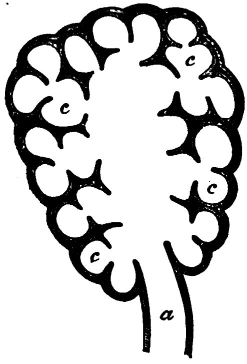

Fig. 23.—Lobule of Lung. *a*, Bronchiole ; *c*, Air-cell.

229. **The Mucous Membrane.**—The mucous membrane lining the air-tubes and cells of the lungs is a very remarkable structure. In the air-passages the membrane is protected by peculiar cells, which by the aid of the microscope are seen to be covered with what look like minute hairs. By the constant movement of these hairs a stream of mucus is kept constantly flowing upward towards the mouth, bringing with it particles of dust which may have been taken in with the breath. In the air-cells the lining membrane is of such marvellous thinness that two thousand five hundred layers would make but an inch in thickness. On account of the immense number of

air-cells and minute air-tubes, the extent of this membrane is so great that if spread over a flat surface it would cover a space of not less than two thousand square feet.

Immediately underneath this delicate membrane, in the walls of the air-cells, is to be found the most remarkable net-work of capillaries in the body. The purpose of this extensive capillary system is to expose to the air, in the most thorough manner possible, all the blood that passes through the lungs.

Covering the entire surface of the mucous membrane and lining the air-cells of the lungs, is a layer of cells which are capable of capturing and destroying the germs of various sorts which are taken in with the breath. In cities, the air contains vast multitudes of germs, which float in the form of fine dust. This living barricade protects the body like a line of faithful and ever-active sentinels. A "cold" weakens these cells, so that the body is thereby rendered less able to defend itself against the attacks of the disease germs which are received through the air. This is the reason why a cold is so often the introduction to pneumonia or some other germ disease.

Alcohol is one of the most efficient means of weakening the lungs, as it invariably causes congestion of these organs, and paralyzes the protecting cells.

Tobacco-smoke is also a most certain means of lessening the ability of the lungs to defend themselves against these most deadly enemies of life and health.

230. **The Pleura.**—The air-cells and the air-tubes are all bound together by means of connective tissue, in which there is a large proportion of yellow elastic fibres, which give to the lung tissue a remarkable degree of

elasticity. The whole is completely enclosed by a serous membrane, the *pleura*, which also lines the chest cavity.

231. **The Thorax.**—The lungs are suspended in a closed box, the chest cavity, or thorax. The sides of the thorax are composed of the ribs, with the muscles and other tissues which cover the ribs and fill the spaces between them. The backbone and the breastbone also help to form the chest walls. The under side of the cavity is closed by a broad muscle, the *diaphragm*, which separates it from the cavity of the abdomen.

232. **The Diaphragm.**—This very important part of the respiratory apparatus is located, as just stated, between the chest and the abdomen. It is a muscular partition, the edges of which are attached to the lower ribs. When at rest, the diaphragm is dome-shaped, rising up into the cavity of the chest. Its hollow undersurface rests upon the liver, stomach, and other organs which occupy the upper part of the abdominal cavity. Besides the diaphragm, there are a number of other muscles attached to the outer surfaces of the ribs which assist in respiration. The abdominal muscles also are of essential use in breathing.

SUMMARY.

1. The chief parts of the respiratory apparatus are the *air-passages*, the *lungs*, and the *thorax*.

2. The air-passages include the *mouth*, *nostrils*, *nasal cavity*, *pharynx*, *soft palate*, *uvula*, *larynx*, *vocal cords*, *epiglottis*, *trachea*, and *bronchial tubes*.

3. The lungs are chiefly made up of bronchial tubes and air-cells, and are covered by the *pleura*.

4. The chief parts of the *thorax* are its framework of *ribs*, the *muscles*, *diaphragm*, and *pleura*.

CHAPTER XVI.

HOW WE BREATHE.

233. **Two Acts in Breathing.** — The air is first received into the lungs, then expelled. The first act is called *inspiration*, the second *expiration*. By enlargement of the chest cavity more room is made in the lungs, and air comes in to occupy the space. By an opposite change the space is diminished, and thus a portion of the air is driven out of the lungs. The size of the chest is increased by the contraction of muscles which draw the ribs upward and outward, and also by contraction of the diaphragm, which enlarges the chest downward. The diaphragm forms the floor of the chest, and, rising and falling, acts somewhat like the piston of a pump. The air is expelled from the lungs by the relaxation of the muscles which enlarge the chest, by the natural elasticity of the lungs, and by the contraction of the abdominal muscles.

The natural action of the lungs is much like that of a pair of bellows, except that the air passes alternately out and in at the same opening. Suppose the trachea to be the nozzle of the bellows, the lungs the body, and the points of the ribs on each side the two handles. When the muscles of inspiration contract, the points of the ribs are separated, just as the handles of a pair of bellows are drawn apart. This is well seen in the breathing of

a long-distance runner and in the panting of a dog. The natural movement of the chest is greatest in the region of the waist.

Respiration is carried on by voluntary muscles, which, by their connection with special nerve centres in the brain, are made to act involuntarily.

234. **Frequency of Respiration.** — The rate of breathing is modified by various conditions and circumstances, as age, position, and exercise. As a rule, the lungs act once for every four heart-beats. The average rate of respiration is sixteen to twenty each minute. We breathe more slowly during sleep. It is not ordinarily possible to hold the breath much more than half a minute, but by first taking several deep inspirations the breath may be held much longer.

235. **Modifications of Respiration.** — *Coughing* is a series of spasmodic expirations. *Hiccough* is a single sudden inspiration, caused by spasmodic contractions of the diaphragm accompanied by closure of the larynx. It is usually caused by gas in the stomach. *Sneezing* is a single violent expiratory effort, in which the air is expelled through both the nose and the mouth. *Sobbing* is a series of short inspirations. *Yawning* is a long inspiration with the mouth widely opened. *Laughing* consists of a series of short expiratory movements, accompanied by agreeable emotions.

236. **Capacity of the Lungs.**—The amount of air taken into the lungs in an ordinary breath is about twenty-five cubic inches, or a little less than a pint. (Compute the amount breathed in twenty-four hours.) The amount of air which the lungs may contain is very much greater than that ordinarily used. After taking an ordinary breath, by a vigorous effort in expanding

the lungs, about one hundred cubic inches more may be inhaled. By a strong effort after breathing out an ordinary breath about one hundred cubic inches more may be expelled. There is left in the lungs continually about one hundred cubic inches which cannot be expelled by a voluntary effort. Adding to these several amounts the twenty-five cubic inches ordinarily inhaled and exhaled, we have three hundred and twenty-five cubic inches as the total contents of the lungs after taking in a very full breath.

237. **Composition of the Air.** — The atmosphere consists of a mixture of two gases, nitrogen and oxygen, with a very small amount of carbonic acid gas, and various other substances in greater or less abundance, according to the degree of impurity of the air. The proportion of the principal elements of the atmosphere is, in one hundred parts of the air, twenty-one parts of oxygen and seventy-nine of nitrogen. For convenience, we may say that the air consists of one part oxygen to four parts nitrogen. The proportion of carbonic acid gas does not exceed, in pure air, four to six parts in ten thousand.

238. **Properties of Oxygen.**—Oxygen is the great supporter of life. Vegetables require oxygen, as do animals. They feed upon carbonic acid gas, separating the carbon from the oxygen, and thus purifying the air; but their life processes depend upon oxygen as much as do those of animals. Oxygen is also the great supporter of combustion or burning. The fire in our stoves and grates requires oxygen to support it, just as animals require this element to maintain life. The more oxygen a fire gets, the brighter it burns. This is why a good draft is essential for a good fire. In undergoing decay,

as well as in burning, substances combine with oxygen. Rotting is really a slow burning. When oxygen combines with any substance, as coal or wood, heat is produced. The more rapid the combination, or burning, the more intense the heat. The slow burning of the rotting log produces just as much heat as would be produced by burning the log in a grate, but it is given off so slowly as to be imperceptible to the senses.

239. **Nitrogen.**—The purpose of this gas seems to be to dilute the oxygen and regulate its supply to the body. It will not support combustion.

240. **Carbonic Acid Gas.**—This gas possesses properties very different from those of oxygen. It will not support combustion. A candle placed in it immediately goes out. Animals die when immersed in it. It is produced in other ways than by burning, as by fermentation, and by all forms of decomposition or decay. The air of fruit-houses, vegetable-cellars, and of brewers' vats often contains a large amount of this gas. It is also produced by chemical actions of various sorts. Great volumes of carbonic acid gas escape from volcanoes. It is also found in coal-mines, where it is known as "choke-damp."

Carbonic acid gas is heavier than air, and hence sometimes collects in low places in which the air is not disturbed, as in unused cellars, deep wells, mines, and sometimes in deep valleys. A good test for this dangerous gas is a lighted candle or taper. Air which contains four parts of the gas in one hundred of air will put out a burning taper when placed in it, and will destroy animal life almost as quickly. This test should be applied before entering a deep well, by letting down a lighted candle. Another test is lime-water, which becomes

milky in appearance when shaken up with air containing carbonic acid gas in any considerable amount.

241. **The "Two Breaths."** — The air which we breathe in and the air which we breathe out are very unlike. We take in at each ordinary breath about twenty-five cubic inches of air, of which about five cubic inches is oxygen, the rest nitrogen. When the air returns from the lungs it is found to have lost one and a quarter cubic inches of oxygen, and gained a cubic inch of carbonic acid gas, together with moisture, heat, and poisonous organic matter.

The amount of water daily expelled from the lungs in the form of watery vapor is estimated at from half a pint to one and one-half pints. (See Experiment 13, page 274.)

242. **A Subtle Poison in the Breath.** — The organic matter which the expired breath contains, although very minute in quantity, is so poisonous in character that a very small amount will render a large volume of air unfit to breathe, and is even capable of producing death if inhaled. The eminent French physician, Dr. Brown-Sequard, recently made some interesting experiments with this poison. He found that a very minute quantity of it injected under the skin of small animals caused almost instant death. An animal made to breathe air contaminated by the breath, and from which the carbonic acid gas has been removed, quickly dies. It is the retention of this poison in the body which so speedily causes the death of an animal deprived of air.

243. **Changes in the Blood during Respiration.** —The changes which occur in the blood during respiration are the opposite of those which occur in the air. It loses carbonic acid gas, moisture, heat, and organic mat-

ter, and gains oxygen. The exchange of carbonic acid gas for oxygen changes the dark purple color of the venous blood to the bright scarlet of arterial blood.

244. **The Assimilation of Oxygen.**—The respiratory process is not confined to the lungs. It only begins and ends in the lungs. Every tissue needs oxygen. A muscle deprived of oxygen soon loses its power to contract. The whole vital machinery stops. Oxygen must be circulated to every cell and tissue in the body. The process of respiration really consists, then, in the inhalation, circulation, and assimilation of oxygen, and the circulation to the lungs and exhalation of carbonic acid gas and organic matter.

245. **Oxygen and Animal Heat.** — One of the objects in breathing is to maintain animal heat. Heat results from the union of oxygen with the elements of the tissues. It is obvious that the more oxygen used in the body, the more heat will be produced. In winter we need more heat than in summer, and the air being denser, we take more oxygen into our lungs.

The amount of heat daily produced within the body is the same as that which would result from the burning of the food daily eaten. The body may be compared to a stove which is kept at a constant temperature by the burning of the fuel placed in it. The body of a grown person gives off in twenty-four hours heat enough to raise one pound of water from zero to the temperature of the body. The adipose or fatty tissue found in all parts of the body, and the glycogen, or animal starch, found chiefly in the liver and muscles, serve as fuel. The process of combustion, or heat production, is most active in the muscles, and is greatly increased by muscular exercise. When little exercise is taken, while the

usual amount of food is still consumed, part of it is deposited as a reserve tissue in the form of fat or glycogen, and the body gains in weight. When an unusual amount of muscular exercise is taken without an increase in the amount of food, the fat or glycogen is consumed in greater quantities, and the body loses in weight. Vigorous exercise is thus a regulator of nutrition, and is the most important means of reducing weight.

SUMMARY.

1. Two acts in breathing, *inspiration* and *expiration*.

2. Natural breathing is like the action of a pair of bellows; as the chest cavity is alternately enlarged and diminished, air is made to pass in and out.

3. The chest cavity is made larger by the contraction of the muscles acting especially upon the sides of the chest, and the contraction of the diaphragm. The movement should be chiefly at the waist.

4. The chest cavity is made smaller by relaxation of muscles, contraction of lungs, and contraction of the abdominal muscles.

5. Breathing is an involuntary act of voluntary muscles; rate about sixteen to twenty per minute; slower during sleep.

6. Coughing, sneezing, laughing, are modifications of the act of respiration; hiccoughing, sobbing, yawning, are modifications of the act of inspiration.

7. The total capacity of the lungs is three hundred and twenty-five cubic inches; the amount ordinarily used in breathing, twenty-five cubic inches.

8. Pure air contains one part of oxygen to four of nitrogen, and four to six parts of carbonic acid gas in ten thousand of air.

9. Oxygen supports life, both animal and vegetable, and also combustion.

10. Carbonic acid gas is a deadly poison to animals. It will not support combustion.

11. Air loses in the lungs one fourth of its oxygen, and gains carbonic acid gas, organic matter, heat, and moisture.

12. The organic matter is the most poisonous element of expired air.

13. Respiration consists of the inhalation, circulation, and assimilation of oxygen, and the circulation and exhalation of carbonic acid gas and organic matter.

CHAPTER XVII.

HYGIENE OF THE LUNGS AND VENTILATION.

246. THE air we breathe is the most essential of all the necessaries of life. Deprived of food, a man may live more than a month; deprived of water, he may live a week; but deprived of air, he will die in a few minutes. Hence it is of the utmost importance that our gaseous food should be abundant in quantity and pure in quality.

247. **What is Impure Air?** — Air which contains so large a proportion of foreign or poisonous elements as to be detrimental to health when habitually inhaled, is impure.

248. **Foul Gases.** — Among the chief impurities found in the air are *foul gases*. The most important of these are *carbonic acid gas*, of which we have already learned; *carbonous oxide*, a still more deadly gas, which escapes from stoves with defective flues or closed dampers in the stove-pipe; and various noxious gases which emanate from sewers, and are known as *sewer gas*.

A few years ago (1885) the newspapers announced the death of five men who were engaged in cleaning a sewer. In this instance death occurred very suddenly, within a few moments of the first unpleasant symptoms. Thousands die every year of slow poisoning from this source.

Poisonous gases of a deadly character are driven

off from *cesspools*, *vaults*, *decaying vegetable or animal matter*, such as is found in *barn-yards*, *animal-pens*, *garbage-heaps*, *vegetable-cellars*, etc.

The great amount of poisonous gases given off by decomposing animal matter is shown by the fact that buzzards and other scavenger-birds may often be seen circling above the carcass of an animal, at so great a distance as to be scarcely visible.

Wall-papers sometimes contaminate the air with poisonous gases from arsenical colors. Mouldy walls, musty closets, damp and musty beds and bedchambers, are other sources of foul gases.

249. **Disease Germs.**—These microscopic forms of life are always present in great numbers in the air about places where animal or vegetable substances are undergoing decay. Foul cellars, neglected cisterns, stagnant pools, are all sources of foul air and germs. We have already learned that germs are the most dangerous of all enemies to life and health.

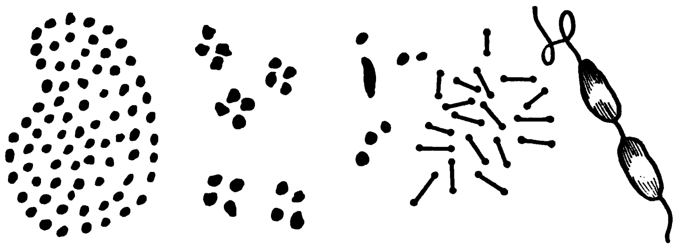

Fig. 24.—Germs. (*Greatly magnified.*)

250. **Sewer Gas.**—Sewers are pipes or passages underground through which filth of various sorts is drained off, usually into some river or large body of

water. Sewers always contain foul air, laden with germs, which is called *sewer gas*. Whenever a house is connected with a sewer there is danger of poisoning from sewer gas. To prevent injury from this source the sewer should be ventilated, before it enters a building, by a pipe running up to the open air; and every sewer-pipe which enters a building should be carried straight up through the building and the roof, so that there may be no accumulation of sewer gas in the pipe.

251. **Coal Gas.**—In cities where coal gas is used for lighting purposes, cases of poisoning frequently occur from carelessness in its use, or from leaky pipes. Coal gas owes its deadly properties to the carbonous oxide which it contains. The recently introduced "water gas" is particularly dangerous, as it consists very largely of carbonous oxide. The greatest care should be taken to prevent contamination of the air with these gases. The slightest odor of gas should be at once traced to its source and the leak stopped. A suffocative gas is given off by kerosene lamps when the flame is turned low. Kerosene stoves give off harmful gases under the same circumstances. Gasolene stoves are particularly dangerous on account of the fact that gasolene vaporizes very rapidly when unconfined, and a mixture of gasolene with air is highly explosive. Many fatal accidents have occurred from the careless use of gasolene.

Night air is by many regarded as exceedingly unwholesome, and they accordingly carefully close windows and doors at night, to exclude it as thoroughly as possible. These persons seem to forget that night air is the only air we have at night, and that we must breathe it if we breathe at all. The air of night is necessarily night air, whether in-doors or out-of-doors. In any case,

pure night air must be more wholesome than air which has been rendered foul by breathing.

252. **Dust.** — Another common impurity of the air is dust from various sources. The little motes which "dance in the sunbeam" are, on examination, found to be "germs" and small particles of many different substances. Dust occurs in connection with some manufacturing industries in such quantities that it becomes a dangerous source of disease, sometimes collecting in the lungs and causing asthma or consumption. Street dust is largely composed of germs. The inhalation of dust of any sort should be carefully avoided.

253. **Air-filters.** — Professor Tyndall, the eminent English scientist, made the useful discovery that cotton-wool is a perfect filter for both dust and germs. Air-filters should always be worn by persons employed in dusty occupations. A cotton handkerchief doubled, and tied closely over the mouth and nose, serves as a very useful filter when one is unavoidably exposed to dust.

254. **Disinfection.**—Sources of germs and foul gases should not be allowed to exist in connection with human dwellings. Foul matters should be removed from the premises at once. Garbage may be burned, or, if not, should be removed daily.

Sunlight, fresh air, and scrupulous cleanliness are among the most efficient of all disinfectants. In dwellings where light and air have free access, mould, mildew, and germs do not flourish. We should admit these powerful disinfectants into our houses as freely as possible. A house or room that has a stale or musty odor is unfit to live in. It should be well disinfected. Pantries, basements, closets, and store-rooms need to be thoroughly cleaned and disinfected frequently. There is no

better practical means for accomplishing this than the burning of sulphur in the place to be disinfected, after it has been thoroughly cleared or cleaned. Chloride of lime is also an excellent disinfectant. In using sulphur for disinfection, burn at least three pounds for each one thousand cubic feet of space to be disinfected. A solution of chloride of lime, one pound to the gallon of water, is useful for the disinfection of drains, and soiled vessels, garments, or surfaces. Further directions respecting the use of disinfectants can be obtained from a physician or a druggist.

255. **Breath-poisoned Air.**—As we have learned, air which has been breathed contains a deadly poison. Small animals placed in such air speedily die. Very small quantities of the poison contained in breathed air may produce disease and ultimate death, even though the immediate effects may not be serious. Consumption is doubtless often caused by breathing air which has been rendered impure by respiration. The headache, colds, loss of appetite, nervousness, and mental dulness with which school children often suffer may be justly charged, in many instances, to breathing impure air in the school-room.

Many years ago one hundred and forty-six English soldiers were taken prisoners of war in India, and shut up in a small room eighteen feet square, having only two small openings on one side. In a short time the air became so poisonous that the most intense suffering began, which resulted in the death of all but a few who were able to keep themselves near the windows. Before midnight many were dead, and at six o'clock in the morning only twenty-six persons still breathed, lying in an unconscious condition. These, being removed to the

open air, were revived, but many of them never fully recovered from the effects of the sufferings of that terrible night.

256. **Ventilation.**—The purpose of ventilation is to exchange the air which has been rendered impure by breathing, or otherwise, for pure air, or to dilute the impure air to such an extent as to render it harmless. Every building occupied either by human beings or by animals should have proper arrangements for the regular and abundant supply of pure air. This is ventilation. There are several facts respecting ventilation which it is very important for us to understand as clearly as possible, and which we may now consider.

257. **How Much Air is Required?**—Careful investigations by Dr. Parkes, of England, and other scientists, show that each breath of expired air renders unfit to be breathed at least two cubic feet or half a barrelful of air. As we breathe eighteen times a minute, a little figuring will show that we spoil at least two thousand cubic feet of air each hour of our lives. It is evident, then, that we require each hour two thousand feet of pure air to take the place of the air which we render impure by breathing.

258. **How to Ventilate.**—In the summer-time, when doors and windows may be widely opened, an abundant supply of fresh air is readily obtained; but in cold weather, when doors and windows cannot be opened without harmful draughts, some regular means of supplying pure air must be relied upon. Each room must have at least two openings—one to admit fresh air, the other to allow impure air to pass out. We may call these openings respectively the *fresh-air inlet* and the *foul-air outlet*.

259. **The Fresh-air Inlet.** — The air should be warmed, before it enters the room, by a furnace or other means, or the fresh air may be warmed by a stove or a steam-coil placed over the fresh-air inlet. The size of the opening should be such as to provide at least eighteen square inches for each person, or thirty square inches if the opening is covered by a register. Ten persons require an opening ten times as large as one person, and for a thousand persons a proportionate amount of space for the admission of fresh air must be provided. The fresh-air inlet may be placed at the floor or at the ceiling, as is most convenient.

260. **The Foul-air Outlet.** — The opening for the outlet of foul air should be placed at the floor if the fresh air is admitted warm. Warm fresh air, on entering a room, rises at once to the ceiling. As it cools, it gradually falls to the level of the floor, at the same time becoming more and more impure. Windows and outside walls are cooler than inside walls, and hence the air falls chiefly at the windows and the outer walls of a room. For this reason, also, it is best to place the foul-air outlet beneath or near a window. The size of the foul-air outlets should be at least as great as that of the fresh-air inlets. It is better that the area of outlets should be somewhat greater than that of inlets. (See Experiment 14, page 274.)

When fresh air is admitted cold, the foul-air outlets should be placed a few feet above the floor, as the pure air, being cold, will be found near the floor, and the most impure in the upper part of a room.

Foul-air openings must be connected with a ventilating shaft in which there is a constant upward draught. A strong draught can best be obtained by heating the

shaft. If the shaft is built in an inside wall, heat in the shaft is not necessary, unless a very strong draught is required, but shafts in outside walls must always be heated to secure a constant and efficient draught, especially in cold weather. The area of a cross section of a ventilating shaft should be equal to the combined areas of the foul-air outlets.

261. **Moisture of the Air.**—A useful constituent of the atmosphere which has not yet been considered is watery vapor, or moisture. The air is capable of dissolving and rendering invisible a considerable amount of water, of which it always contains more or less. If the air is too dry the exchange of gases in the lungs does not take place readily, and when the air is saturated with moisture it does not readily take up the moisture which should escape from the lungs, and with which the organic poison of the breath is removed. The action of the skin is also lessened in an excessively moist atmosphere. The interference with the action of these two important organs is the cause of the discomfort experienced in a warm, moist atmosphere, as just before a rain on a hot day.

In winter-time, when the air which enters our houses may be so dry as to be injurious to health and productive of discomfort, we may add moisture to the air by boiling water. It is for this purpose that hot-air furnaces are supplied with water-pans.

262. **Lung Hygiene.** — Having secured an ample supply of pure air by suitable ventilation, it is important that it should be properly used. We may breathe more rapidly or less rapidly, deeper or more superficially, as we choose. We may expand our lungs so that they will exchange nearly a gallon at each breath, or we

may make so little effort in breathing that only a few cubic inches of air pass in and out the lungs as we breathe. Thus it becomes a matter of importance that we should attend carefully to the manner in which we breathe. The whole chest should be expanded. Civilized women generally use only the upper part of the

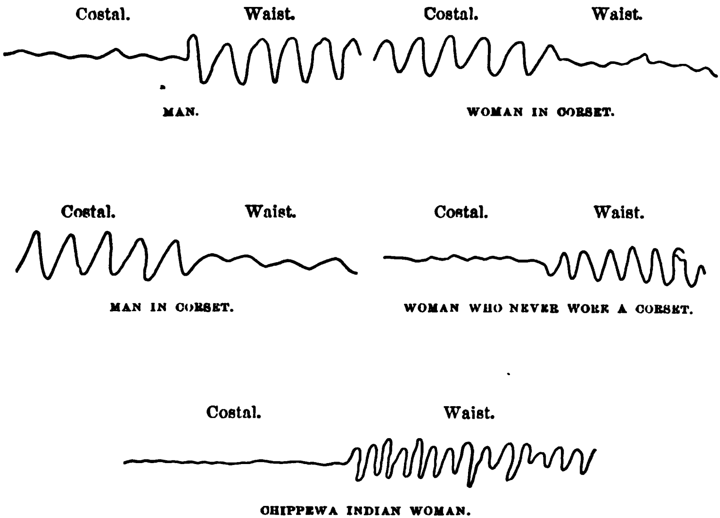

Fig. 25.—Breathing Movements as Registered by the Pneumograph.

lungs, their unhealthful mode of dress making it impossible for them to use the lower part of the chest properly, while men expand the lower part of the chest most. Among savages, men and women breathe alike.

By the aid of the pneumograph the author has made many careful observations among Indian and Chinese women, who wear their clothing loose about the waist,

the Yuma Indians of New Mexico, and other Indian tribes, who have not yet adopted the civilized mode of dress, the peasant women of Italy, and in Paris among women known as models, who are not allowed to wear corsets or tight bands, and has been unable to discover anything suggesting the slightest difference between the natural mode of breathing in men and in women. The accompanying cuts are exact copies of tracings of the respiratory movements obtained by the author by the aid of the pneumograph. The first half of each tracing shows the movements made by the upper part of the chest in ordinary breathing, the second half the movements of the lower part of the chest. It will be at once seen that the tracing produced by the breathing of the Chinese woman is the same in character with that obtained from a man, while that obtained from the corset-wearing woman is just the reverse.

For healthful breathing it is necessary that the clothing should be loose at the waist. To wear the clothing tight at the waist is as absurd as to tie the handles of a pair of bellows needed for constant use, and cripples the lungs in precisely the same manner. The lower part of the chest is so constructed as to allow of easy expansion, while the upper part is completely enclosed by bones and cartilages. Women and girls, as well as men and boys, should accustom themselves to the use of the whole chest by daily vigorous exercise in loose garments. It is especially important to cultivate the use of the lower portion of the chest and of the abdominal muscles.

Students and persons whose occupations do not give them an abundance of arm exercise should devote at least one-half hour daily to such special exercises as will strengthen the muscles of the arms and chest. The use

of wooden dumb-bells and Indian clubs is excellent for this purpose. What are known as "free-hand movements" of the arms are also useful. Simply raising the extended arms from the side upward as far as possible, keeping the shoulders well thrown back, and rising upon tiptoe at the same time, is a good exercise for the lungs. The movements should be repeated at the rate of about ten or twelve a minute, and continued for ten minutes two or three times a day.

The action of the diaphragm is important in reference to other organs besides the lungs. It aids digestion by a sort of kneading action upon the stomach. It compresses the liver, empties it of its stagnant blood, and forces the bile into its proper channels. It hastens the sluggish current of the portal circulation, and thus aids in the absorption of digested food by the mucous membrane of the stomach and the intestines. Its great importance demands that it should be allowed to act without the restraint of tight stays or waistbands. The practice of tight lacing, so common among civilized women (though not practised by the women of any *un*civilized tribe yet discovered), is so exceedingly harmful, and productive of such wide-spread injury in the body, that it can scarcely be considered less than criminal when practised by a person who has been informed of its evils.

263. **Colds.** — A cold is often a more serious matter than many persons suppose. A "cold in the head" is the common cause of nasal catarrh, a very annoying and often offensive disease. A "cold on the lungs" may lay the foundation for fatal disease of these organs. The greatest care should be taken to avoid colds. An excellent means to prevent taking cold is a cool sponge bath taken every morning. Never neglect a cold.

264. **Mouth-breathing.**—Many persons acquire the very harmful habit of breathing through the mouth. Air should always enter the lungs through the nose. The nose not only acts as a strainer but warms the air, moistens it to some extent when it is too dry, and warns us of danger when it is impure. Mouth-breathing is the cause of snoring. It is usually occasioned by some disease of the nose which obstructs the nasal passages. As a result of habitual mouth-breathing, the lungs become diseased, and frequently a peculiar deformity of the chest, familiarly known as "pigeon breast," is produced. Sometimes, also, as a result of mouth-breathing, the features become unpleasantly distorted, the upper lip being shortened and the upper teeth projecting. A physician should always be consulted when mouth-breathing is found to be constant.

265. **Suffocation and Drowning** require the use of artificial respiration, which should be applied intelligently and patiently for half an hour or longer, if necessary. (See Experiment 15, page 275.) In the mean time keep the patient warm by the use of hot bottles.

When a person must be exposed to noxious gases or smoke, as in escaping from a burning building, suffocation may be prevented by taking several very deep breaths before the exposure, as this will enable one to hold the breath for a much longer time than usual. If obliged to go through hot smoke and gases, tie a wet handkerchief over the mouth and nose before making the attempt, and keep the head as near the floor as possible.

266. **Choking.**—As we have elsewhere learned, substances swallowed are prevented from entering the air-passages by means of the epiglottis. If one is trying

to speak and eat or drink at the same time, the epiglottis sometimes fails to close properly, so that substances may enter the larynx and cause choking. Death has resulted from the injury to the lung caused by so small an object as a kernel of corn. Larger objects may produce death by obstructing the breath. A choking person should be held head downward. If relief is not speedily obtained by this means, a few smart blows between the shoulders will often dislodge the foreign body. If these measures do not succeed promptly, send for a surgeon at once.

267. **Injurious Effects of Alcohol.**—The effect of alcohol in predisposing to inflammation of the bronchial tubes, pneumonia, and various other grave diseases of the lungs, is well known to physicians. Alcohol dilates the small blood-vessels of the lungs as well as those of other parts of the body, and thus invites congestion and inflammation. Alcohol was once regarded as an excellent remedy for consumption, and was very generally recommended as such by physicians; but recent studies of this subject have shown that alcohol is itself a cause of one of the most hopeless forms of consumption.

268. **Tobacco.**—Smoking is a very common cause of serious disease of the throat. Sometimes cancer of the throat results from excessive smoking. Cigarette-smoking is also a cause of disease of the nose as well as of the lungs. The use of tobacco in any form is detrimental to the health of the lungs, since it injures the whole body, lowers vitality, and hence lessens the resistance to disease.

The breath of the tobacco-user is evidence of the polluted state of his body. His brain, nerves, muscles—all the tissues—are flavored with nicotine. His blood is

loaded with the poison, which it carries to the lungs, liver, kidneys, and skin for elimination. This accounts for the odor which hangs upon the breath of the smoker often for hours or days after his last cigar or pipe. His whole body is saturated with the poison.

SUMMARY.

1. Chief air impurities—*carbonic acid gas, carbonous oxide, sewer gas, gases of decay, coal gas, kerosene and gasolene gas, germs, dust, poison of the breath.*
2. *Germs* are the most dangerous of all.
3. Disinfectants—*pure air, sunlight, fire, sulphur fumes, chloride of lime.*
4. Amount of air needed—2000 cubic feet per hour for each person.
5. Two openings required—*inlet, outlet.*
6. Admit warm air near floor, allowing thirty inches of register surface for each person.
7. The foul-air outlet should at least equal the inlet in size, and should be placed at the floor and connected with a ventilating shaft.
8. Lung exercise is needed. Expand chest at waist; use diaphragm and waist muscles.
9. Proper breathing specially aids the stomach and the liver as well as the whole body.
10. Mouth-breathing is very injurious to health.
11. For suffocation or drowning, employ warmth and artificial respiration.
12. Alcohol causes inflammation of lungs and consumption.
13. Tobacco-using causes disease of throat and nose.

CHAPTER XVIII.

THE VOICE AND SPEECH.

269. **The Larynx.**—As we have already learned, the larynx is the organ of the voice. It is a cartilaginous box, placed between the windpipe and the pharynx. The location of the larynx is indicated by the prominence familiarly known as "Adam's apple."

Within the larynx are found two bands of tissue which stretch across it, called the *vocal cords*. By

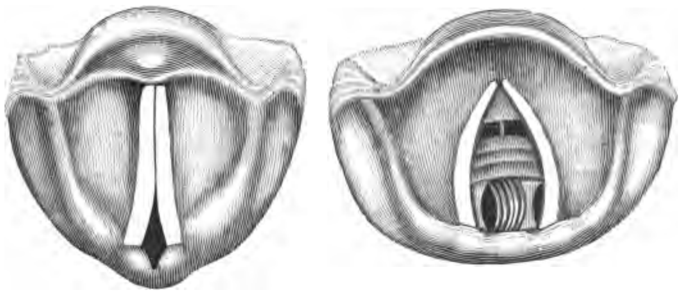

Fig. 26.—Vocal Cords.

means of various muscles, the vocal cords may be stretched tightly or relaxed, drawn together, or separated from each other. The upper opening into the larynx is guarded by the *epiglottis*, which has been elsewhere described.

270. **Voice.**—When the vocal cords are brought together, and air is forced through between them, they are made to vibrate, producing a sound. This is the *voice.* When the vocal cords are long or loosely stretched, the voice is low in pitch. When the cords are short, or tightly stretched, the pitch is high. A grown person has a larger larynx than a child, and hence longer vocal cords and a voice of lower pitch. As a child develops, the larynx enlarges, especially between the ages of fourteen and eighteen. This is the reason why the voice changes at this period of life. A man has a larger larynx, and hence a voice of lower pitch, than a woman.

271. **Speech** is produced by modifications of the voice made by the tongue, teeth, lips, and throat. Whispered speech is produced by making the usual movements of the mouth without using the vocal cords.

The singing voice differs from the ordinary voice only in the fact that a succession of sounds having a harmonious relation is uttered, instead of mere vocal sounds or words without relation to harmony or musical laws. The volume of the voice depends chiefly upon the size of the vocal organs, the quality upon their form and that of the nasal cavity. The range of the ordinary voice is scarcely two octaves, but the voices of some celebrated singers have had a range of three or four octaves. The limits of the human voice are represented by 42 vibrations per second for the lowest tone, and over 2000 vibrations per second for the highest.

272. **The Hygiene of the Voice.**—Avoid taking cold. If a cold has been taken, and is accompanied by hoarseness, the voice should not be used in singing or loud speaking until the hoarseness is relieved. Permanent injury to the voice often results from disregarding

this rule. Never overstrain the voice. Cultivate full tones, using the muscles of the waist in singing and speaking instead of the upper part of the chest. The practice of intoning is injurious to the voice, inducing chronic inflammation, which destroys the finer qualities of the voice. The use of rich foods and irritating condiments or sauces impairs the voice, by producing congestion of the throat.

273. **Alcohol and Tobacco.**—The use of alcohol or tobacco frequently causes loss of voice or great and irreparable injury to it. The deep-toned voice of the beer-drinker is an indication of chronic inflammation of the larynx, a disease to which drinkers of beer are subject. Tobacco-users, particularly smokers, are seldom free from disease of the throat. The hot, irritating smoke, brought into contact with the delicate vocal cords, is productive of almost certain mischief. Singers and public speakers are often obliged to abandon the use of tobacco on this account.

SUMMARY.

1. Voice is produced by the vibration of the vocal cords; speech, by modifications of the voice by the tongue, teeth, lips, and palate.
2. Frequent colds, the use of condiments, and the practice of intoning injure the voice. In singing and loud speaking, use the diaphragm and the abdominal muscles, and expand the lower part of the chest.
3. Alcohol and tobacco cause disease of the throat and loss of voice.

CHAPTER XIX.

THE SKIN AND THE KIDNEYS.

274. **The Skin.**—The skin covers the entire body. At the openings of the body it joins the "lining skin," or mucous membrane. The skin is a very elastic tissue, and may be stretched to a surprising extent, as is seen in cases of great obesity or dropsy. This is due to the fact that the basis of its structure is a mesh-work of connective tissue, in which yellow elastic tissue abounds.

The total area of the skin in an adult of average size is estimated to be about seventeen and one-half square feet.

275. **The Cuticle.**—The skin is divided into two distinct layers. The outer, known as the *scarfskin*, *cuticle*, or *epidermis*, is composed of flattened cells, arranged in several layers. The deepest layers of the epidermis contain cells in which are colored granules, to which is due the color of the skin. In the white races the color granules are very few in number, while in the dark races they are very abundant. In the albino, the color cells are absent, so that the cuticle is nearly transparent, and shows the pink color of the tissues beneath.

The scarfskin contains no blood-vessels and few nerves, and hence is not sensitive, and does not bleed when cut. By scraping the skin with a sharp knife the scarfskin may be removed without pain. In a blister, the cuticle is separated from the true skin. The epi-

dermis is constantly shed, being rubbed off by the friction of the clothing and contact with other objects. After taking a warm bath, the outer and older layers of

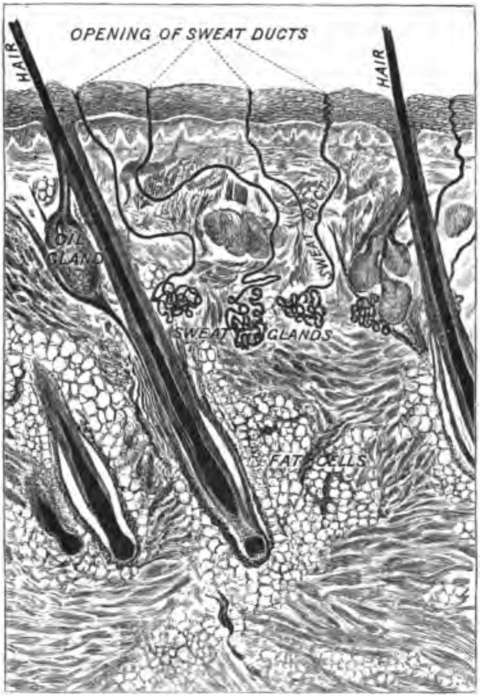

Fig. 27.—The Structure of the Skin.

cells may be rubbed off in considerable quantity by the aid of a flesh-brush or a coarse towel. Soap and alkalies soften the dead cuticle and aid in its removal. The chief use of the cuticle is to cover and protect the sensitive structures beneath it.

276. **The True Skin.**—The deep layer of the skin, called the *dermis*, or true skin, contains many blood-vessels, glands, and nerves. The true skin also contains many involuntary muscular fibres, most of which are connected with hairs. The contraction of these fibres gives rise to the condition commonly termed "goose flesh."

277. **The Perspiratory Glands.**—By looking closely at the palm of the hand with a magnifying-glass (such a glass as is used by students in the study of flowers will answer very well), numerous depressions may be seen all along the summits of the fine ridges which appear on this portion of the skin. These depressions mark the openings of the so-called pores of the skin. Each is the mouth of a minute duct or tube, which runs down into the deep parts of the dermis, where it is curved upon itself in such a manner as to form a delicate coil, known as a *perspiratory* or *sweat gland*.

The number of sweat glands and ducts in the entire skin is not less than two and one-half millions, making a total length of several miles.

278. **The Perspiration.**—The perspiratory glands constantly pour out upon the skin a fluid excretion, the *perspiration*, or *sweat*, which consists of water and various impurities separated from the blood by the glands. In some parts of the body, as in the armpits, these glands are more numerous than in other parts. Ordinarily, the perspiration escapes by evaporation as rapidly as produced, so that it is unnoticed, and on this account is termed *insensible perspiration.* The amount of insensible perspiration produced daily by the entire skin is usually from one and one-half to four pints. Extreme heat, active exercise, and other causes may give rise to

much more profuse secretion, which becomes visible as sweat or sensible perspiration. When one is in a very damp atmosphere, the perspiration is not evaporated with ordinary rapidity, and hence becomes visible. In fever the sweat glands are often paralyzed, so that the skin is dry, notwithstanding the excessive heat. The importance of the perspiration as an excretory fluid is well shown by the ill consequences which result when the action of the skin is checked, as in taking cold.

279. **The Sebaceous Secretion.**—In addition to the sweat glands, there are to be found in the skin little glands known as *sebaceous* or *oil glands*, which form and pour upon the skin an oily substance, the purpose of which is to protect and lubricate the skin and to soften the hair.

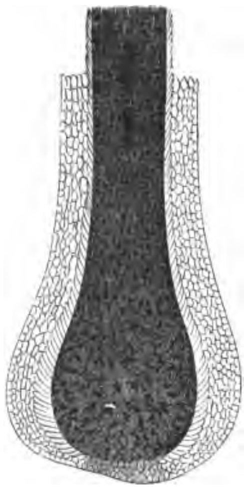

Fig. 28.—The Root of a Hair.

280. **The Hair.**—Hairs are found upon all parts of the surface of the body, with the exception of the palms of the hands and the soles of the feet. Each hair grows from a pouch in the skin, which extends into its deepest parts. Many of the sebaceous glands discharge their secretion into the hair tubes. The color of the hair is due to the presence of colored granules like those which give the skin its color.

281. **Uses of the Hair.**—The uses of the hair seem to be chiefly (1) to protect the skin or parts beneath from changes of temperature, as in the case of the head; (2) to protect sensitive parts from dust or other foreign substances, as do the

eyelashes and eyebrows, and the hairs of the nostrils and of the external canal of the ear; (3) to serve as an aid to the sense of touch.

282. **The Nails.**—These structures, like the hair, are appendages of the cuticle, or scarfskin. They grow from a little fold of the skin, and from the tissues which they overlay. Their use is to protect the ends of the fingers and toes, to increase the delicacy of the sense of touch, and to aid the fingers in picking up small objects.

283. **Uses of the Skin.**—The skin is one of the most important organs of the body. Its chief uses are, (1) protection; (2) sensation—pain, touch, temperature; (3) excretion; (4) absorption; (5) respiration—absorption of oxygen and exhalation of carbonic acid gas; (6) regulation of temperature.

The last-named use is probably one of the most important functions of the skin. The internal temperature of the body, as we have elsewhere learned, is maintained at 98½° Fahr. At all seasons and in all countries the variation within the limits of health is scarcely more than one degree, notwithstanding the fact that the temperature of the air may vary from 70° Fahr. below zero, in the arctic regions, to 150° Fahr. above zero in the sultry deserts of Northern Africa.

It is evident that the body must possess some means by which its temperature may be nicely regulated or adjusted to the temperature of the surrounding atmosphere. When we become much heated, we perspire freely. If we sit down in the shade after violent exercise on a warm day, as the perspiration dries off we feel cool, or even chilly. From this common experience we learn that the object of profuse sweating is to cool the body. This is accomplished by evaporation, which is a

powerful means of lowering the temperature. The body is being cooled in this way continually by the evaporation of the insensible perspiration.

284. **Relation of the Skin to other Organs.**—When the action of the skin is suddenly checked, extra labor is thrown upon the lungs, liver, and kidneys, especially the latter. This may result in serious disease. Inflammation of the kidneys is often caused in this way.

An animal, if covered with varnish, dies in eight or ten hours. At the coronation of Pope Leo X. a small boy was covered with gold-leaf to represent a cherub. In a short time he became very sick and in a few hours died, in spite of all that the most skilful physicians could do for him, poisoned by retained perspiration.

285. **The Kidneys.**—These important organs are located at the back part of the abdominal cavity, just below the last ribs. They are placed close to the spinal column, one on each side. Their shape is that of a kidney-bean. Their weight is from four to six ounces each.

Fig. 29.—Section of Kidney.

286. **Structure of the Kidneys.**—The minute structure of the kidneys is remarkably similar to that of the true skin, which it also resembles in its functions. When examined under the microscope, the substance of the kidney is found to be largely made up of very delicate tubes, which begin near the surface of the organ in delicate little round sacs, each of which contains a minute blood-vessel coiled up, as is shown in Figure 29. These

tubes combine as they pass towards the centre, becoming larger in size, and finally opening into a cavity in the kidney. This cavity communicates with a long tube, the *ureter*, which passes downward and empties into a large muscular sac, the *bladder*, located in the pelvis.

287. **The Urinary Excretion.**—This is one of the most important of all the excretions, containing some of the most poisonous of the waste elements of the body. When from any cause the action of the kidneys ceases, the individual dies in a few hours, with all the symptoms of poisoning.

SUMMARY.

1. The skin is an elastic membrane, composed of two distinct layers,—the outer called the *cuticle*, or *epidermis*, and the inner the *dermis*, or true skin.

2 The cuticle is made up of several layers of cells, the lowest of which contains the coloring matter of the skin.

3. The true skin contains nerves, blood-vessels, the sweat glands, and the sebaceous or oil glands.

4. The amount of perspiration produced daily is one-half pint to two pints.

5. The hair and the nails are appendages of the cuticle. They serve to protect the parts from which they grow.

6. The uses of the skin are *protection, excretion, absorption, regulation of the temperature* of the body, and *respiration*. The skin is also an organ of *sensation*.

7. The kidneys resemble the skin in structure and function.

8. Their secretion is conveyed by the *ureters* to the *bladder*.

9. The *urinary excretion* is one of the most important of all the excretions of the body.

CHAPTER XX.

HYGIENE OF THE SKIN AND THE KIDNEYS.

The two great requirements of health, as regards the skin, are proper clothing and cleanliness. These two conditions are as necessary for the health of the body in general as for that of the skin, and hence should receive ample and careful attention.

288. **Cosmetics.**—The various lotions, powders, paints, creams, etc., which are sold for the purpose of beautifying the complexion, are to be looked upon with suspicion. Many of them are worthless; others are dangerous, not only injuring the skin, but producing grave disease. A form of paralysis which frequently occurs from this cause is known as "wrist-drop," from the fact that the hands hang down when the arms are stretched out, the patient not being able to raise them. Thorough cleanliness of the skin of the face, using soft water, either cold or tepid, aided by a little fine soap, is generally all the cosmetic required. A healthy skin is usually clear and beautiful, although there are, of course, differences in complexion, due to the amount and distribution of the coloring matter. Muddiness of the complexion is usually the result of bad diet and imperfect excretion. It may generally be made to disappear by the aid of proper bathing and care in diet, abstaining from rich foods, especially pastry, pork, and sausage.

289. **Care of the Hair.**—The free use of hair-oils is

not necessary, and is decidedly unwholesome. Nature has provided the hair with oil glands, which pour out their secretion at the root of each hair, thus furnishing a natural dressing. If the scalp is kept in a healthy condition by frequent cleansing and daily brushing, a sufficient amount of oil will be produced to give the hair the desired lustre and softness. Hair-oils become rancid in the hair and gather dust: they should be avoided.

Gray hair is the result of the failure of the cells which form the hair to produce the proper amount of pigment. It may be the natural result of age, or may be produced early in life by disease.

Many of the "*hair-dyes*" and "*hair restoratives*" which are sold are poisonous, and are harmful both to the hair and to the general health. The use of hair-dyes by old persons to conceal their age is not in good taste, and rarely accomplishes the purpose desired.

290. **Care of the Nails.**—The ends of the nails should never be bitten or torn off, but should be carefully trimmed with a sharp knife or scissors. The skin at the root of the nail should be carefully pushed back once or twice a week, to prevent its clinging to the nail and becoming torn. When the growth of the nail lengthwise is interfered with, as when a person wears a shoe or boot which is too short or narrow at the toe, the side of the nail often grows down into the flesh, producing an *ingrowing nail.*

291. **Corns and Callus** are due to excessive development of the cuticle, or scarfskin. They are usually the result of wearing tight or badly fitting shoes or boots. They may be easily removed, but will return so long as the cause remains.

292. **Burns and Scalds** are the result of exposure to

excessive heat, dry or moist. If the skin is injured through its entire thickness, a serious scar will be left behind. The pain of a burn is best relieved by applying moistened soda and protecting the part from the air. Submersion in water is one of the best means of treating a serious burn.

293. **Effects of Alcohol and Tobacco upon the Skin.**—Not even the skin escapes the ravages of these powerful poisons. The drunkard's nose and face show clearly the injury which alcohol is working in his body. The tawny skin of the tobacco devotee distils through its pores the foul poison which, having permeated every other organ, leaves behind its stain upon the delicate tissues of the beautiful covering of the body.

294. **Effects of Other Narcotics.**—It is well known that coffee produces a peculiar muddiness of complexion. Tea also stains the skin, and opium destroys its natural life and vigor, so that the practised eye discovers the morphia slave at once by his dead and expressionless countenance.

295. **Hygiene of the Kidneys.**—These organs are in close sympathy with the skin. Whatever causes inactivity of the skin imposes extra labor upon the kidneys and renders them liable to disease; and whatever encourages the action of the skin lightens the labor of the kidneys. Sedentary habits, neglect of the bath, exposure to severe cold, the use of irritating condiments, excessive use of flesh food, and, above all, the use of alcoholic liquors, may be mentioned as the chief causes of kidney diseases, which are increasing in this country at an alarming rate.

296. **Effects of Alcohol on the Kidneys.**—Strong liquors affect the kidneys, as they do the liver and all

other parts of the body with which they come in direct contact. Degenerations and inflammations are set up, which finally result in the destruction of these important organs and of life. Kidney diseases which result from the use of alcoholic liquors are the most hopeless of all maladies of this class. The effect of beer in exciting the kidneys to excessive action is well known. The extra labor thrown upon the kidneys by the free use of ale and beer is a common cause of Bright's disease, one form of which is more frequent among beer-drinkers than among any other class of persons. The evidence of kidney disease may often be seen in the bloated and dropsical appearance of habitual drinkers. Those who call themselves moderate drinkers do not escape this part of the penalty which nature inflicts upon those who gratify the appetite for alcohol regardless of the possible consequences.

A part of the work of the kidneys is to remove from the blood poisonous substances which are produced in the stomach and intestines as the result of indigestion, and to carry out of the system food substances which have been taken into the blood without being perfectly digested. The liver completes the work of digestion. When it becomes so disabled from the use of alcohol that it cannot do its delicate work efficiently, some portions of the food are allowed to pass into the general circulation without having been so changed by the liver as to make them serviceable in building up the body or supplying its wants. These unusable substances the kidneys are compelled to remove, so far as they are able to do so. This is a great addition to their usual work.

We see, then, that when a person uses alcoholic drinks the mischief wrought by the poison multiplies itself.

1. The alcohol renders the stomach unable to digest the food properly, and consequently extra work is imposed upon the liver. 2. It impairs the ability of the liver to perform its ordinary duties, besides putting upon it the double labor of endeavoring to complete the imperfect work done by the stomach, and to remove the alcohol. 3. The kidneys are not only disabled by the alcohol, but are compelled to remove a portion of it from the body, and also the poisonous and unusable substances resulting from the injury to the stomach and the liver. This same principle prevails throughout the body. One evil resulting from alcohol creates another, and so the mischief is multiplied.

297. **Tobacco and Kidney Disease.**—Recent scientific observations go to show that the use of tobacco is a frequent cause of serious disease of the kidneys. A very grave malady, known as "Bright's disease" of the kidneys, has been traced to the use of tobacco. It is more than probable that the mischief done by this exceedingly poisonous drug is yet very imperfectly known. Its use is so general that the evils resulting from it are very easily overlooked, or are ascribed to some other cause than the right one. As a large part of the poison is carried off through the kidneys, it is inevitable that they should suffer in a special manner from its influence.

It is a common thing to find in smokers a condition in which the odor of tobacco "hangs on the breath"; that is, the penetrating odor of nicotine is always present, although the individual may have abstained from smoking several hours or even several days. This condition is due to the fact that the kidneys have become diseased, so that they are unable to remove the nicotine from the system as fast as it is taken in, and hence it

accumulates in the system, saturating every organ, every cell, every nerve fibre, the blood, and all the vital fluids. A person who is thus saturated with a violent poison is certainly not in a fit condition to realize whether or not he is suffering from its effects. His benumbed sensibilities give no warning of the mischief which is being wrought in his system, and the danger which threatens life as well as health.

298. **Harmful Drugs.**—Many of the various drugs administered for the cure of disease are removed from the body by the kidneys. Some of these, when used for a considerable time, produce serious disease of the kidneys. Many of the patent medicines with which so many persons dose themselves almost continually, and especially the long list of liver and kidney "regulators," "cures," etc., are exceedingly harmful to these organs. Most of those who take patent medicines for kidney disease have no disease of the sort, until disease is produced by the drugs which they swallow.

SUMMARY.

1. The conditions most essential for the health of the skin are proper clothing and cleanliness.
2. *Cosmetics* are harmful and sometimes dangerous.
3. The hair should be kept healthy by cleanliness of the scalp and daily brushing.
4. "Muddiness" of the skin is generally due to bad air and bad diet.
5. Alcohol, tobacco, and most other narcotics injure the health of the skin and destroy its beauty.
6. Neglect of the bath, the use of irritating condiments, excessive use of flesh food, and exposure to cold cause disease of the kidneys.
7. The use of alcoholic liquors and tobacco causes Bright's disease of the kidneys.
8. The use of "kidney medicines" is unwise, and even dangerous.

CHAPTER XXI.

BATHING.

299. **Necessity for Bathing.**—More than two million sweat glands are constantly pouring out upon the surface of the body a stream of waste matter in solution, which amounts to a considerable quantity in the course of a day. The watery portion evaporates, leaving a thin scale of organic filth over the whole surface of the body. At the same time millions of little cells which compose the cuticle lose their vitality, and are replaced by younger ones pressing up from beneath. The secretion of the oil glands, dust, and other impurities added to the substances deposited from the sweat, form upon the skin, even within so short a time as twenty-four hours, a layer of impurities which needs to be removed.

300. **Effects of Water upon the Skin.**—When cool or cold water is applied to the skin, the blood-vessels contract, but quickly relax, causing an increased circulation of blood in the skin, or a "reaction." If a person remains too long in a cold bath this reaction does not occur, or is overcome, and the sensation of chilliness lasts a long time. Prolonged cold bathing is rarely useful. It is often very harmful, and may even be dangerous. The effect of a hot bath is to relax the blood-vessels and to induce sweating. Heat stimulates the sweat glands and causes profuse perspiration. The heart

also beats stronger and more rapidly, so that the brain becomes congested. Very hot baths are rarely useful and may do much mischief.

301. **Proper Temperature of Baths.**—Water which will cause the appearance of goose-flesh when the arm is held in it for a moment is *cold*. That which is near the temperature of the body is warm. That which is above the bodily temperature is *hot*. Warm baths should not be taken too frequently. A cool bath may be taken two or three times a week with advantage.

302. **How to Bathe.**—It would be unnecessary to instruct an East Indian how to bathe, for he practises the art every day of his life almost from earliest infancy; but among most civilized nations bathing is practised far less frequently than it should be. A sponge and towel, with two or three quarts of water, are the essentials for a simple sponge or towel bath. Begin by washing the face and neck and wetting the top of the head. Next apply the wet sponge to the chest, arms, and shoulders, then to the rest of the trunk, and lastly to the legs and feet. Rub a little soap into the armpits and all the creases of the body before applying the water. Have a large dry sheet or one or two towels in readiness. Dry quickly, and then rub the skin with a coarse towel, a soft flesh-brush, or a bath-mitten, until it glows; then dress and exercise for a few minutes. If the room is cool, or if the person chills easily, he should bathe only a small portion of the body at a time, drying the part bathed before wetting another.

303. **The Full Bath.**—This bath is taken in a tub of sufficient size to allow the whole body to be immersed, with the exception of the head. A little soap should be used. The general tendency is to take such baths too

warm. The temperature of the water should not be over 90° to 98° Fahr. After such a bath, especially in damp or cold weather, a little fine oil, as olive or cocoanut oil, should be applied to the skin to replace the natural covering of oil. This is especially important when a warm bath has been taken for the relief of a cold.

304. **Rules for Bathing.**—The following rules are important:

1. Do not bathe just before or soon after eating.
2. Be careful to dry the skin thoroughly, not neglecting the feet, before dressing.
3. Exercise vigorously after a cold bath. Rest after a warm bath.
4. Never take a cold bath when exhausted or when perspiring.
5. If giddy or faint in a bath, leave it at once, lie down, sip cold water, and apply cold water to the face and the head.

SUMMARY.

1. Frequent bathing is made necessary by the accumulation of waste matter, dead cells, oil, and foreign substances upon the surface of the body.
2. Water not only cleanses the skin, but stimulates the circulation of blood through it.
3. The beneficial effects of cool bathing are due to the reaction produced.
4. Cold bathing is seldom beneficial and often does harm.
5. Very hot baths are sometimes unsafe, and are seldom needed.
6. Baths should be taken with careful regard to proper rules.

CHAPTER XXII.

CLOTHING.

305. **What to Wear for Health.** — The materials usually worn in clothing are *linen*, *cotton*, *silk*, and *wool*, to which must be added *leather* for shoes and *rubber* for over-shoes and over-garments.

Linen has the advantage of being smooth, soft, and light, but is an inferior material for clothing, particularly for under-garments. A linen garment feels cold and wet when in the least degree moist. *Cotton* is a better material for clothing to be worn next the skin, especially in warm weather. *Silk* is still better, but *wool* is best of all (Experiment 16, page 275). The only objection to wool is that it is sometimes irritating to the skin, and so cannot be worn with comfort. In such cases a thin cotton or silk garment may be worn under the woollen. *Rubbers* and *mackintosh coats* retain the perspiration in the clothing, on which account care should be taken to change or dry the clothing after wearing rubber protectors for any length of time (Experiment 17, page 275).

306. **Clothing should be Adapted to the Season and Weather.**—More clothing is of course necessary in winter than in summer, but the amount of clothing required varies less than the temperature.

In man, as well as in lower animals, the system undergoes a change with each season of the year, by which it

adapts itself to new conditions. This change produces what is termed the "winter constitution" in winter, and the "summer constitution" in summer. The "winter constitution" is well adapted to resist cold, while the "summer constitution" is prepared to resist heat; consequently, conditions the reverse of those for which the body is prepared are severely felt.

On this account we need more clothing in summer than in winter, even when the temperature of the air is the same.

The fashion of putting off and putting on winter or summer clothing at certain dates, as is customary with many persons, is a mischievous one. A change from warm to cold weather, or the reverse, at any season of the year, should always be met by a corresponding change in clothing. The outer garments may remain the same, but the under-garments should be modified from day to day as the weather may indicate. Observance of this rule will amply repay the necessary trouble in the saving of sickness and consequent expense and loss of time.

307. **Clothing of the Feet.**—Many persons permit their feet and limbs to be so thinly clad in cold weather that they are never properly warm. In children their development is checked, and a large part of the blood which the feet and limbs should contain is crowded into the head and other organs, which already have a full supply, thus doing double mischief. Young children and aged people require more clothing than adults.

Tight shoes or boots prevent the proper circulation of the blood in the feet, and produce corns, bunions, swellings, and sometimes still more serious diseases of the feet. High heels throw the weight of the body too

much forward, and French heels, which are set forward under the foot, transfer the weight to the hollow of the foot, which is not at all fitted to bear weight. The wearing of such shoes breaks down the instep, producing the condition known as "flat-foot," and renders a graceful carriage of the body impossible. The stockings should be held in place by supporters, and not by tight elastics (Experiment 18, page 276).

308. **Clothing of the Neck and the Head.**—Colds and sore throats most often result from exposure of the head and throat. If the head and the throat were never covered they would learn to take care of themselves, as does the face; but when covered most of the time, and then occasionally exposed, colds are easily contracted. Coverings for the head and the throat should be sufficient for comfort in cold weather, but not so warm as to cause perspiration, as this will insure taking cold. Extra wrappings about the throat should be worn only when required by reason of unusual exposure.

309. **Evils of Tight Lacing.**—Proper breathing requires unrestrained action of the muscles of the chest and abdomen. If the waist is compressed by tight clothing the breathing is seriously interfered with, and not only are the lungs thereby rendered liable to disease, but the whole body suffers from the insufficient supply of air. Oxygen is needed to cleanse the tissues, and it is no wonder that the young lady who foolishly laces her clothing tightly, under the mistaken notion that beauty demands a small round waist for a good figure, loses her clear, rosy complexion, and becomes pale and sallow.

Pressure upon the waist also does great mischief by displacing internal organs. The liver and the stomach

are often crowded out of position, and so cruelly compressed that they become permanently deformed. Physicians often meet cases in which examination shows the liver to be nearly cut in two by this outrageous violation of nature's laws. Under such circumstances, it is of course impossible that the stomach and the liver should be able to do their work properly. (Figs. 30 and 31.)

The fashionable Chinese mother bandages the feet of her little girls in such a manner as to dwarf their growth and produce almost incredible deformity. The process is accompanied by very great pain, but is insisted upon for the purpose of conforming to the absurd custom which demands that the foot of an aristocratic Chinese woman shall be simply a rounded stump, so that it may be squeezed into a very small shoe. The author once measured a shoe worn by a Chinese lady, and found it to be exactly three inches in length. Ridiculous as this custom is, it is no more worthy of condemnation than the wearing of tight, high-heeled French shoes, so commonly worn at the present day by fashionable women in civilized lands.

310. **Tight Lacing and Gall-stones.**—Women suffer from gall-stones and jaundice very much more frequently than do men, which is doubtless due to the fact that compression of the waist involves direct pressure upon the liver, and restrains the action of the diaphragm. In consequence, the liver and gall-bladder are not well emptied of bile, and the secretion becomes hardened into masses termed *gall-stones*. Women and girls, as well as men and boys, should wear their clothing so loose that the lower part of the chest can be fully expanded.

311. **Change of Clothing.**—The clothing, especially that worn next the skin, absorbs a large amount of the

waste matters thrown off by the skin, and so becomes charged with impurities. On this account the under-clothing should be changed not less often than once a

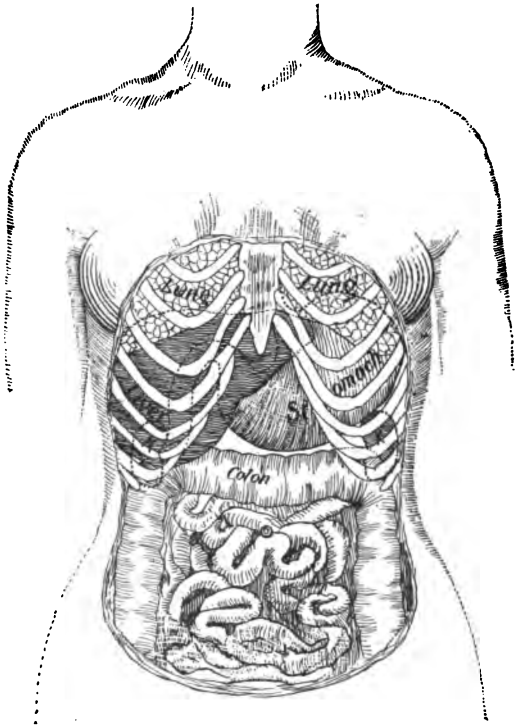

Fig. 30.—NATURAL FORM.

week in winter. In the summer season, and whenever the skin is unusually active, health will be promoted by a daily change. In cold weather the comfort of the feet,

if they are inclined to be cold, will be greatly promoted by a daily change of the stockings.

312. **Night Clothing.**—The clothing worn during the

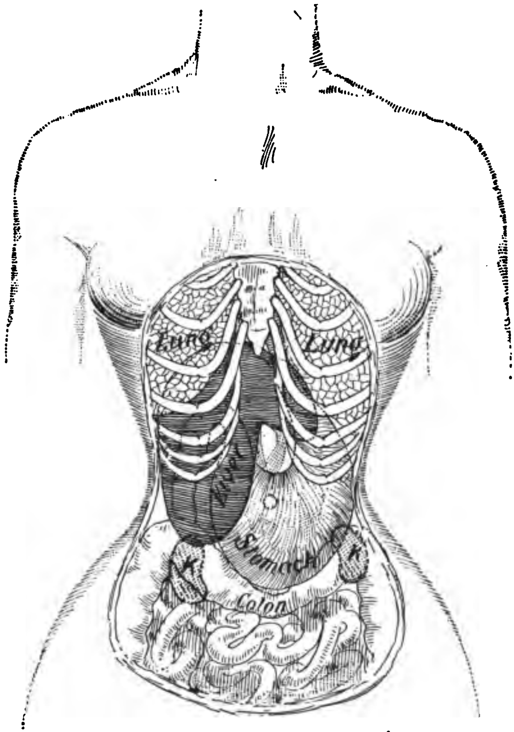

Fig. 31.—THE RESULTS OF UNHEALTHFUL DRESS.

night should exclude every article worn during the day. In winter-time a long woollen bed-gown is as necessary for health as for comfort. When the feet and extremities are cold, woollen bed-socks should be worn in addition.

313. **Beds.**—The bedclothing should be dry and warm. A cold bed is necessarily a damp bed, as it condenses moisture from the body of the sleeper, as well as from the air of the room. A damp bed becomes musty. A person sleeping in such a bed is not only debilitated by the loss of animal heat, but is poisoned by the inhalation of musty, germ-laden air, which he is compelled to breathe during at least a third of the twenty-four hours.

Bedclothing should be of porous material, so that the exhalations from the skin may not be retained in contact with the body, to be reabsorbed. Feather-beds absorb so readily and retain so tenaciously the exhalations of the body that they are justly regarded as objectionable. Bed-covers and mattresses should be thoroughly aired daily, and should be exposed to the direct rays of the sun when possible, or dried before a fire.

A sleeping-room should always contain a heater, unless warmed by a furnace or from an adjoining and communicating room. A grate is the most healthful mode of heating a sleeping-room. The bedroom should not be too warm, but should be heated sufficiently each day to insure dryness. Sleeping in a room which is too warm is enervating and unrefreshing. The temperature of a sleeping-room for healthy persons should be little above 50° F. Infants and aged persons require a higher temperature, as do also feeble invalids.

314. **Poisonous Colors.**—Numerous cases have occurred in which serious illness, accompanied by painful inflammation of the skin, has arisen from wearing articles of clothing colored with poisonous dyes. Flannel under-garments, stockings, and colored hat-bands are the most frequent means of communicating the poison. Red and other *aniline colors* are most likely to be

poisonous. New stockings and under-garments, if colored, should be well washed before they are worn.

SUMMARY.

1. The materials used for clothing are valuable, from a health standpoint, in the order named: *wool*, *silk*, *cotton*, *linen*.
2. The clothing should be adapted to the season of the year, and to changes in the weather at all seasons.
3. The clothing should be so arranged as to secure equable warmth. Infants and aged persons require extra warmth.
4. The clothing should be so adjusted as to allow perfect freedom of movement in all parts of the body.
5. Shoes with narrow toes, and high or French heels, produce serious disease of the feet and other organs.
6. Clothing worn during the day should not be worn at night.
7. Bedclothing should be aired, and, if possible, exposed to the sun daily.
8. Impervious material should be worn only a few hours at a time, and should not be used as bedclothing.
9. Eruptions and inflammation of the skin are sometimes produced by clothing colored with poisonous dyes.

CHAPTER XXIII.

THE BONES: THEIR USES, AND HOW TO CARE FOR THEM.

THE framework of the body, the *skeleton*, supports the various structures and organs. The simplest form of a skeleton is nothing more than a stony or horny framework over which a soft animal substance is spread. The common sponge is a skeleton of this sort.

315. **The Structure of Bones.**—The human skeleton is a much more complicated and perfect structure. It consists of many different parts, each wonderfully suited to its use. There are three sorts of structures found in the skeleton—*bones*, *cartilages*, and *ligaments*.

The bones are the hardest tissues in the body. Bones are covered by a tough membrane known as *periosteum*. The periosteum sends into the bone numerous blood-vessels and a few nerves, through which the bone is developed and nourished.

Experiments made for the purpose of determining the strength of solid bony tissue show that it will resist greater pressure than the strongest oak.

Long cylindrical bones, like the bones of the thigh, are hollow, and the interior is lined with a membrane similar to that which covers the surface. The cavities of hollow bones are filled with a substance chiefly composed of fat and blood-vessels, the *marrow*.

The large bones of the arms and legs are *long* bones

The ribs and the bones of the upper part of the skull are *flat* bones. The little bones of the wrist are *short* bones. Most of the bones of the face are *irregular* bones.

316. **Cartilage.** — This is a tough, elastic substance, which composes the greater portion of the bones in early life. As we grow older, the cartilage for the most part hardens into bone.

Fig. 32. — Section of a Long Bone.

317. **The Joints.** — The points at which bones join are termed *joints*. There are in the human skeleton many joints, most of which are movable. Some joints move with very great freedom, as the shoulder; others have less motion, as the elbow; and still others have no motion. The structures of a movable joint are: 1. The *cartilages*, which cover the ends of the bones forming the joint. 2. The *ligaments*, which bind the parts of the joints firmly together. 3. A delicate membrane which encloses the joint called the *synovial membrane*. This membrane secretes a limpid fluid by which the joint is lubricated, the *synovial fluid*.

There are several kinds of movable joints, as the *hinge-joint*, of which the elbow and the finger joints are examples, the *ball-and-socket* joint, as seen in the shoulder, and joints in which two flat surfaces glide over each other, as in the bones of the wrist.

318. **The Skeleton.** — The entire skeleton consists of just two hundred bones, twenty-two of which are found in the head, fifty-two in the trunk, sixty-four in the upper extremities, and sixty-two in the lower extremities.

319. **Bones of the Skull and Face.**—Eight of the bones of the head are united in such a manner as to form a hollow case called the skull, in which the brain is safely lodged. The form and structure of the skull are such as to afford the greatest amount of strength and protection with the least weight of material. The skull presents a number of small openings for the passage of nerves and blood-vessels, and at the lower back part is a very large opening through which the spinal cord passes to join the brain. Fourteen of the bones of the head belong to the face. Two of these form the bridge of the nose, two the prominent parts of the cheek, two the upper jaw, one the bony partition of the nasal cavity, and one the lower jaw. The others line the cavities of the nose and mouth. The two jaw bones contain sockets for the teeth.

It sometimes occurs, in the development of the body, that the bones or soft tissues of the upper jaw fail to unite completely, leaving a deficiency which is known as "hare-lip."

320. **The Bones of the Trunk** consist of the following: Twenty-four *vertebræ*, which compose the backbone; an equal number of *ribs;* the *sacrum*, a bone of peculiar shape, which joins the lower end of the spine; the *coccyx*, a small bone added to the lower end of the sacrum; the *breastbone* or *sternum;* and the *hyoid* bone, a small bony ring which is placed just under the lower jaw, and supports the root of the tongue. The form and position of each of the principal bones is shown in Figure 33.

321. **The Spinal Column.**—This remarkable bony structure is so made that it may bend with ease in any direction with the movements of the trunk of the body,

and without occasioning inconvenience to the delicate parts which it protects. This wonderful result is accomplished by the arrangement of a number of separate bones, one above another, each of which is called a *vertebra.* Each vertebra has a thick portion called its body, a ring-shaped portion, and several projections. The latter are for the attachment of the ribs and the ligaments by which the several vertebræ are held together. When arranged one above another, with the bodies and rings of each in corresponding positions, a bony column is formed with a canal extending through its entire length. This is called the *spinal column.*

Fig. 33.—The Skeleton.

The upper vertebræ are so peculiarly shaped as to

enable the head to "nod," and to be turned from side to side. By the combination of these two movements the head may be turned in every direction. The vertebræ are separated from each other by means of disks composed of very elastic cartilage.

In consequence of this arrangement of the spinal column, a person who is much on his feet becomes shorter during the day, through thinning of the cartilages between the vertebræ, and regains his height during the night. Most persons are half an inch taller in the morning than at night.

322. **The Ribs.** — These bones connect the spinal column with the sternum. The first seven are called *true ribs*, because they are connected with the breastbone, each by a separate cartilage. Of the remaining five, known as *false ribs*, three are joined to one cartilage, which connects them to the sternum, and two are left unconnected. These latter are termed *floating ribs.*

323. **The Thorax.** — The spine, the ribs, the sternum, and the diaphragm enclose a cavity which is called the thorax. This cavity contains the heart, the lungs, large blood-vessels, and other important organs.

324. **The Pelvis.** — This is the name given to the cavity enclosed between the sacrum and the coccyx and the two large bones which form the hips. The pelvis contains the bladder and other important organs.

325. **The Upper Extremity, or Arm,** consists of the following bones: The *shoulder-blade*, or *scapula;* the *collar-bone*, or *clavicle;* the *upper-arm bone*, or *humerus;* the two bones of the *fore-arm—radius* and *ulna;* the eight bones of the wrist; and the nineteen bones of the hand.

326. **The Lower Extremity** consists of the *hip-*

bone; the *thigh-bone,* or *femur;* two *leg-bones—tibia* and *fibula;* the *knee-cap,* or *patella;* seven *ankle-bones;* and the nineteen bones of the *foot.*

The bones of the foot are so arranged as to form an arch, the instep, which adds greatly to the strength and beauty of the foot. When this arch becomes broken down, as it sometimes does from wearing ill-fitting shoes or boots, a person becomes flat-footed, and cannot walk far without great fatigue and discomfort.

327. **Composition of the Bones.** — The remarkable firmness and solidity of bony structures is due to the large amount of organized salts which they contain. When burned, a bone is found to lose one-third its weight, though retaining its form. This shows that only about one-third of its weight is animal matter. The remaining two-thirds consists chiefly of phosphate of lime, which constitutes more than one-half the entire weight of the bone. About one-ninth of the weight of the bone consists of carbonate of lime, or chalk. Of course there is neither phosphate of lime nor chalk in living bone. These elements are found after the bone has been burned, being formed out of the organized salts which exist in the living bone (Experiment 19, page 276).

Fig. 34.—Bone Deprived of Earthy Matter.

If a fresh bone is placed for a few days in a dilute acid, the earthy matter will be dissolved out. It will then be found that the bone has lost two-thirds of its weight, and that the portion remaining, while of the same form as before, will have lost its firmness, and

become so flexible that if the bone is long and slender, as a rib of a sheep, it may easily be tied in a knot. The portion left constitutes the animal matter of the bone and consists chiefly of gelatine.

328. **The Bones in Infancy and Old Age.**—From infancy to old age the bones acquire an increasing amount of earthy matter. On this account the bones are more brittle in old age, and less easily broken in infancy and childhood.

329. **Uses of the Bones.**—The chief uses of the bones are: 1. To support the soft parts of the body. 2. To protect delicate and sensitive parts. 3. In connection with the muscles, to move the body and its various parts. On each bone is found raised or roughened places, ridges, etc., to which, in life, muscles are attached. By the connection of the muscles with the bones, the latter are used as levers to do the work of the body and to move it about. 4. Recent discoveries have shown that the red marrow of the bones is active in producing blood corpuscles.

SUMMARY.

1. The skeleton is composed of *bones, cartilages*, and *ligaments*.

2. The general divisions of the skeleton are: Head, 22 bones; trunk, 52; upper limbs, 64; lower limbs, 62.

3. The head comprises—skull, 8 bones; face, 14.

4. The trunk comprises—vertebræ, 24 bones; ribs, 24; sternum, hyoid, sacrum, and coccyx.

5. Each upper limb comprises—scapula, clavicle, humerus, ulna, radius, 8 bones of the wrist, and 19 bones of the hand.

6. Each lower limb comprises—hip, femur, tibia, fibula, patella, 7 bones of the ankle, 19 bones of the foot.

7. The joints are formed by bones, cartilages, ligaments, synovial membrane, and are lubricated by synovial fluid.

8. The bones constitute a framework for the body, protect delicate parts, and serve as levers. The red marrow makes red corpuscles.

CHAPTER XXIV.

HYGIENE OF THE BONES.

In order that they may be properly developed, the bones must be supplied with food containing an abundance of "salts," the kind of nutrient elements which they especially require. These are found in their best form in milk and in whole-grain preparations. *Rickets*, a disease in which the bones are affected so seriously that great deformity often results, is very probably due, in part at least, to a lack of this element in the food.

Exercise should be carefully adapted to a person's age and development. The flexible bones of young children sometimes become seriously bent, as in cases of "bow-leg" and "bandy-leg"—deformities which are the result of allowing an infant to walk before its bones are sufficiently firm to support the weight of the body without bending. Exercise is necessary for the proper development of the bones.

Spinal curvatures, *round shoulders*, *flat chest*, and other deformities result from sitting in improper positions, a habit usually formed at school. This is a matter to which teachers and parents should give attention, as the mischief done in early years can seldom be wholly corrected by the most skilful treatment afterwards. The deformities of the trunk and the feet which result from improper dress have been elsewhere considered.

330. **Injuries of the Bones and the Joints.**—

When a bone is broken, the muscles often draw the ends of the bone apart, so that a skilled physician is required to put them in proper position. After being "set," they must be retained in position by splints and bandages until nature has time to cement the parts together by means of a substance produced between and around the ends of the broken bone. This cement substance gradually hardens, and after a time becomes as firm as bone, and makes the bone nearly as good as before.

In consequence of a blow or a fall, the end of a bone is sometimes *dislocated*, or "put out of joint." In some cases the displaced bone may be readily restored to its proper position, but often this can be done only with great difficulty. On the occurrence of such an accident a skilful surgeon should be called at once.

A *sprain* is an injury due to a strain of a joint by a misstep or otherwise, as the result of which a ligament is lacerated or torn from its fastenings to the bone. A bad sprain may be more serious than a fracture. A *bunion* is a painful swelling over a joint, caused by irritation of the synovial membrane, which is usually due to the pressure of a tight or badly fitting boot or shoe.

331. **Alcohol and Tobacco.** — The effect of these poisons in preventing the proper development of the bones is so apparent that even those who defend their use by adults do not hesitate to condemn their use by those who have not yet attained maturity. A boy who early begins to smoke cigars or cigarettes, or to use alcoholic drinks, is very likely to be dwarfed in body and mind. Even the bones, in some cases, will not develop properly. Doubtless, grown persons who use tobacco suffer equally, though differently. The effect of alcohol or tobacco upon a boy is to check his growth; upon a

man, to shorten his life. The effects upon grown persons, though sometimes less apparent, are none the less positive. Certainly the character of these poisons is not changed by the age of the person who uses them.

The important function of the red marrow of the bones in producing blood corpuscles must be seriously interfered with by the poisonous influence of alcohol and tobacco. The peculiar pallor of smokers and chronic drinkers is perhaps due in large part to this poisonous effect of these injurious agents. Any agent which paralyzes the blood-making organs of the body, or impairs their activity, must be most destructive to life and health. As has been elsewhere shown in this work, alcohol and tobacco are poisons, and destructive to all living cells, whether animal or vegetable. When these poisons are circulated in the blood, their injurious influence is exerted upon every cell and tissue in the body. Their influence upon other blood-making organs, as well as the red marrow of the bones, must be in the highest degree detrimental to health and vigor.

SUMMARY.

1. Bones require for their development food containing an abundance of "salts," which are especially found in whole-grain preparations.
2. Exercise must be adapted to the age and to the stage of development.
3. Deformities of the bones often result from improper positions, especially in sitting at school.
4. The use of alcohol and tobacco by young persons prevents the proper development of the bones, as well as the growth of other parts of the body.

CHAPTER XXV.

ANATOMY AND PHYSIOLOGY OF THE MUSCLES.

332. **Muscular Fibres.**—A muscle is chiefly composed of minute fibres, each of which possesses in a remarkable degree the property of contractility. A piece of lean corned-beef, when boiled, may be easily separated into small bundles. These bundles may, by the use of needles, be "teased" out into fine fibres, which, under a small magnifying-glass, may be separated into fibres still smaller. These last minute threads of animal substance are the muscular fibres. (Fig. 35.) The fibres of a muscle are held together by a sheath of connective tissue.

Fig. 35.—Muscular Fibre.

The total number of separate muscles in the body is about five hundred. The muscles vary in size from a certain muscle in the leg, which in a tall man is nearly two feet in length, to the delicate little muscles of the ear, to see which one almost requires a magnifying-glass. The muscles constitute that portion of the body which in lower animals is commonly known as lean meat.

333. **Tendons.**—In its ordinary form a muscle consists of a fleshy central portion, the muscle proper, joined

at each end to a white cord-like structure, chiefly composed of white fibrous tissue, and known as *tendon*. By means of the tendons the muscles are firmly attached to the bones. Each muscle has usually two points of attachment. The one which is least movable, or which is nearest the centre of the body, is termed the *origin;* the other, the *insertion*. Some muscles have tendons at each end, others at the point of insertion only, while still others have none at all.

334. **Forms of Muscles.**—Some muscles are shaped like a spindle; others like a feather; still others are spread out like a fan, and a few have the form of a ring. These structures adapt themselves in a most interesting manner to the varying needs of the body.

335. **Two Classes of Muscles.**—Besides the muscles which chiefly constitute the fleshy portion of the body, and which we are able to use at will, there are muscles of a very distinct class, mostly found in the interior of the body, which act according to the needs of the body, and quite independent of the will. The walls of the hollow organs—the stomach, intestines, bladder, and blood vessels—are in part made up of this kind of muscular tissue. Those muscles which are controlled by the will are termed *voluntary muscles;* those not under control of the will are called *involuntary muscles*.

Those muscles which are not under the control of the will have a structure very different from that of voluntary muscles. When examined with a microscope, they are found to consist of spindle-shaped cells closely interwoven. The muscle tissue of the heart is of a mixed character, resembling both voluntary and involuntary muscular tissue.

336. **The Muscles of the Face.**—The upper part of

the skull is covered by two muscles, one on each side, extending from the eyebrows to the back part of the head. By contracting this muscle we wrinkle the skin of the forehead. Other little muscles, attached to the skin of the forehead in different positions, enable us to elevate the eyebrows, as when we look surprised, or to draw them down, as in scowling. The nose is furnished with muscles which enlarge and contract the nostrils. Several powerful muscles connect the lower jaw with the upper, and also with the skull, by means of which we are able to open and close the mouth in speaking and in eating, as well as in various expressions.

337. **Muscles of Expression.** — A large circular muscle surrounds the mouth, enabling us to contract it, as in puckering the lips. Attached to this circular muscle are little muscles running off to various parts of the bones and skin of the face. Some draw the corners of the mouth up, and others draw them down. Some elevate the lips, others depress them. These various muscles, acting with other muscles of the face, give to the countenance its wonderful and ever-varying expression. Every emotion of the mind has thus its shadow in the face. It is evident that if a certain class of thoughts is constantly affecting the face so as to make its muscles contract habitually in a particular way, the face will after a time retain permanently the expression given to it by the action of these muscles. It is thus that the face becomes an index to the character. The proper training of the muscles of the face is an important part of one's education.

338. **Muscles of the Trunk.** — The muscles of the trunk are very numerous, and are arranged in layers. Those of the upper part assist in inspiration. Those of

the lower part aid expiration, enclose the abdominal cavity, and, acting with the muscles of the back, hold the body erect, and execute most of the movements of which the trunk is capable. The muscle which forms the partition between the cavity of the chest and that of the abdomen is called the *diaphragm.* It is the most important muscle of respiration.

339. **Muscles of the Arm.** — The arm muscles are fifty-eight in number. The upper arm is acted upon by eleven muscles, some of which connect the arm with the trunk; others connect the upper arm with the fore-arm. The largest of these are the *pectoral*, which forms the fleshy part of the chest, the *biceps*, which forms the front part of the upper arm, and the *triceps*, which forms the back part of the upper arm. These muscles give to the arm a great variety of movements. The fore-arm has four principal movements: bending, or *flexion;* unbending, or *extension;* turning inward so as to bring the palm of the hand downward, or *pronation;* and turning outward, or *supination.* These movements are accomplished by thirteen muscles. The wrist joint is controlled by sixteen different muscles, which give to it great freedom and variety of movement. The muscles of the thumb and fingers are eighteen in number, and enable these organs to execute a great number of movements.

340. **Muscles of the Lower Extremity.** — The thigh is moved by twenty distinct muscles, most of which arise from the trunk. Three of these compose the fleshy portion of the hip. The muscles which move the *leg* are ten in number. The largest is the *rectus*, which forms the front of the thigh. One of the most remarkable is the *sartorius*, or tailor's muscle, so called because

it is used in crossing the legs under the body as tailors often do at their work. It is the longest muscle in the body.

The foot and toes are controlled by twenty muscles, the two largest of which form the calf of the leg and are joined to the heel by the *tendo-achilles*. The toes move much less freely than the fingers, though in infants, whose feet have not been cramped by badly fitting shoes, they are capable of a considerable degree of movement. Persons born without hands sometimes learn to use the feet and toes in writing and sewing.

341. **How a Muscle Contracts.**—The contraction of a muscle consists in the shortening of the many fibres of which it is composed. In shortening, each fibre thickens, so that the actual size of the muscle is not materially changed. If the tendon of a muscle is cut, the muscle at once contracts, which shows that it is always a little stretched, even when at rest. This is necessary to secure steadiness and promptness in muscular movements. Most movements, as those of the arms and legs—even the simple act of standing erect—require the harmonious action of many muscles, each of which is balanced against some other one, thus enabling us to execute steady and graceful movements.

342. **Involuntary Muscular Action.**—The action of involuntary muscles is not prompt and vigorous as that of voluntary muscles. It is slow, rhythmical, and is said to be constant in a state of health. The heart muscle partakes of the properties of both voluntary and involuntary muscles, to which fact is due its capacity for such vigorous and continuous work.

343. **Amount of Work Done by the Muscles.**—All the perceptible movements of the body are the result

of muscular action. It has been calculated that the muscles employed by a common laborer in doing an ordinary day's work perform an amount of work equivalent to lifting 1000 tons. A horse does seven times as much work as a man. The most rapid movements possible to human muscles are eight or ten a second; but birds and insects make much more rapid movements.

It has been calculated that, in rowing, an oarsman in a well-trained crew does work equal to lifting four tons one foot high every minute, which in one hour and forty minutes amounts to a full day's work for an ordinary laborer. Many creatures smaller than man are much more powerful in proportion to their size. A man can scarcely leap two or three times his own length, but a flea or a grasshopper will leap two or three hundred times its length. Imagine a creature with the legs of a flea, the wings of a dragon-fly, a pair of jaws and a coat of mail like those of a beetle, and magnified to the size of an elephant! Such a creature could leap from the north to the south pole at a few bounds, could crush the strongest steel in its jaws, and resist a cannon-ball with its armor.

344. **The Muscles as Machines.** — When a man uses a crow-bar to pry a stone out of the ground, he employs it as a lever. There are several kinds of levers,

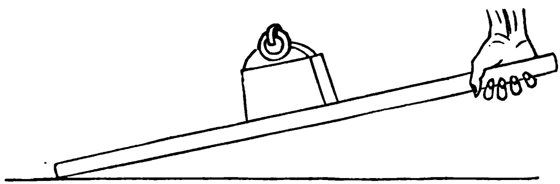

Fig. 36.—A Lever.

all of which are illustrated in the human body in the arrangements of the muscles with the bones. The bones are the levers, the muscles apply the power, and the various objects moved, the body itself or its parts, are the weights lifted.

345. **The Hands.** — The human hand, in the great variety and precision of movements of which it is capable, is approached by no similar organ possessed by any other animal. Its chief utility arises from the power to oppose the thumb to the fingers. The hand of the ape is by no means so perfect as the human hand. By training, the hand may acquire a degree of skill and dexterity which is truly marvellous.

346. **Use of the Legs.** — The many muscles which compose the fleshy part of the limbs are, some of them, in constant activity except when the body is in a reclining position. In *standing*, many muscles are constantly active in steadying the body and in holding it erect. *Walking*, *running*, and *leaping* are different modes of using the limbs in moving from one place to another. Running differs from walking in that the two feet are off the ground at the same time, though one is in advance of the other. In leaping, the two feet are off the ground at once, and are together.

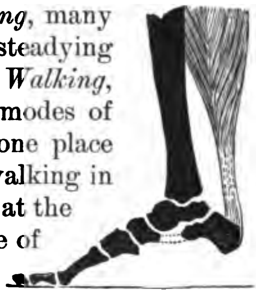

Fig. 37. — Action of the Muscles of the Foot in Walking.

347. **Other Uses of the Muscles.** — The use of muscles in expression, in speaking, and in breathing, has already been referred to, as well as their connection with the processes of digestion and circulation. The muscles are also useful in giving to the body symmetry and grace of form and movement,

covering up the rugged angularities of the bones, and rounding out the figure.

Another important use of the muscles is by their activity to regulate nutrition. The muscles are the chief source of bodily heat, and consume the greater part of the material which is taken in as food. Any portion of food which is not immediately used is stored as reserve tissue. This stored material serves the body as does the coal a locomotive. If more food is taken than is consumed by the muscles, the reserve tissue will increase, and obesity will be the result. By regulating the amount of exercise proportionately to the amount of food taken, the weight of the body may be maintained at an equilibrium.

348. **The Muscular Sense.**—It is by means of the *muscular sense*, termed the *sense of weight*, that we are able to judge of the weight of one object as compared with that of another. The muscles possess sensibility to pain in less degree than does the skin.

SUMMARY.

1. A muscle is composed of minute contractile fibres.
2. There are in the body about five hundred muscles of various forms.
3. Muscles are joined to bones by tendons.
4. There are two general classes of muscles, *voluntary* and *involuntary*.
5. Principal groups of muscles: Muscles of the head and the face; of expression; of the trunk—hold body erect, enclose abdomen, aid respiration; of the arms, 58 in number—upper arm 11, fore-arm 13, wrist 16, thumb and fingers 18; of the lower limbs, 50 in number—thigh 20, leg 10, foot and toes 20.
6. Names of some of the principal muscles of the body: *Pectoral biceps, triceps, diaphragm, rectus, sartorius.*
7. The muscles use the bones as levers.
8. The muscles are the seat of a special sense, the *sense of weight.*

CHAPTER XXVI.

HOW TO KEEP THE MUSCLES HEALTHY.

349. **Exercise.** — The first condition essential for the health of the muscular system is regular and systematic exercise. It is a law of nature that an unused organ dwindles away until it becomes quite useless. When not in action, a muscle is pale, and receives little blood. When active, the supply of blood is greatly increased. Exercise stimulates growth. The effects of exercise are well shown in the arms of the blacksmith and the wood-chopper. Their arm muscles are large and hard, while those of persons who use the arms but little in vigorous exercise, as students, lawyers, editors, and most professional men, are thin and soft.

When not used at all, the muscles become stiff, as well as weak and flabby; that is, they will not readily respond to the orders sent them by the will. The joints also become stiff, so that movement is slow and painful, and may become impossible. Regular daily exercise keeps the muscles strong and supple, and the joints flexible.

350. **Effect of Exercise on other Organs.** — Exercise is as essential for the health of the body in general as for that of the muscles. The heart and the breathing muscles are especially influenced by exercise. A person who exercises little gets out of breath easily; while one who is accustomed to rapid walking or run-

ning has a "good wind." By regular exercise, the heart and the breathing muscles become strong, and, in consequence, the blood is circulated better, and a larger amount of oxygen is received into the body, thus imparting vigor and life to all the tissues.

351. **How to Exercise.**—To be thoroughly useful, exercise must be taken regularly, and must bring into vigorous action all the muscles of the body, and especially those that are least used in the daily business. For girls, general housework, sweeping, dusting, making beds, and similar household employments, afford excellent exercise, bringing into play the whole muscular system in an admirable manner. The confinement in-doors, however, is objectionable. All persons whose employment is sedentary, or in-doors, should take out-of-door exercise daily.

For boys, no general exercise excels that which may be secured in "doing chores" about the house. Splitting and carrying wood, running errands, and engaging in the numberless varied employments included under the head of "chores," if heartily entered into, secure ample exercise for all parts of the body. When really enjoyed, muscular labor of some sort affords a most useful form of exercise. It should be added that even those who engage in muscular employments may take with benefit various exercises for the purpose of bringing into action muscles which are not much used in the daily labor. Such persons require special exercises to secure equal and symmetrical development of the body.

352. **Gymnastic Exercises** are invaluable as a means of general exercise for all classes, and especially for students and young persons. Properly managed, they call into action all the muscles of the body in the manner

best calculated to secure beneficial results. Many excellent exercises may be taken in the school-room at intervals during the day with great advantage, even if but four or five minutes at a time are devoted to them. It is better still to set apart in every school and every home a room where exercises may be taken at stated hours under proper supervision. The simple apparatus needed may be provided at small expense.

353. **Mental Influence of Manual Training.**— One of the most important results of exercise is its influence upon the mind. This sort of culture increases not only muscular power, but brain and nerve power as well. Every muscular contraction requires the action of the brain and nerves to produce it, so that muscular exercise is also nerve exercise; and by it the nerves as well as the muscles are made more vigorous and efficient. The difference between a body well trained and developed and one that is not, is enormous. A body whose every muscle is trained to precision of movement is as much more efficient and useful than an untrained body as the well-trained horse is more serviceable than the clumsy, unbroken colt. Vigorous muscular exercise is conducive to good morals, by maintaining a state of high health. A young man who feels a just pride in his physical strength will avoid evil practices, in order to preserve his vigor.

By prolonged and systematic practice the strength of the muscles may be enormously increased. Dr. Winship, a man of medium size, after many years of practice became able to lift with ease the enormous weight of two thousand eight hundred pounds.

354. **Symmetrical Development.**— It is important that the body should be developed symmetrically; that

is, that the two sides should be trained alike. Most persons are right-handed. In consequence of constant training, the right hand and arm become not only larger and stronger than the left, but more skilful. Right-handed persons always employ the right hand to do anything requiring dexterity. If we should give equal attention to the left hand, it would become equally large, strong, and useful. The ability to use both hands equally well would almost double their usefulness.

Violent exercises of every description should be avoided, especially by young persons. Many of the games so popular among school-boys and young men are harmful, on account of the extremely violent exertions likely to be made in the excitement of the game. A person who has not been accustomed to vigorous exercise should begin with very light exercise, always stopping short of extreme fatigue, and increasing the amount of muscular work from day to day.

Physiologists have observed the curious fact that if a muscle is stimulated when it is weighted with a load greater than it can lift, it elongates at the moment of action instead of shortening. This very clearly shows the danger of attempting to lift weights so heavy as to require violent straining, or to engage in any kind of exercise requiring excessive muscular efforts. By this overstretching, the muscles may be permanently weakened.

355. **Unrestrained Movement Necessary.** — A muscle which is hampered by the pressure of tight or badly fitting clothing performs its work very imperfectly indeed. Very firm pressure will temporarily paralyze a muscle by preventing the expansion which must accompany contraction (Experiment 20, page 276). The breath-

Fig. 38.—IMPROPER POSITION.

ing organs especially should have the greatest freedom of movement during exercise.

356. **Effects of Improper Positions.**—"As the twig is bent, so the tree is inclined," is an adage which applies with full force to the human body. Its yielding structures readily mould themselves into unnatural and unhealthful forms when the body is allowed to assume positions which favor such changes. This is especially true during infancy and childhood, when the bony framework of the body is still soft and yielding. Unhealthful postures may be assumed in *sleeping*, *sitting*, *standing*, or *walking*. These erroneous postures may produce deformity, and predispose to disease. Children should be carefully taught to maintain proper positions, so that all parts of the body may develop equally and healthfully.

Fig. 39.—PROPER POSITION.

357. **Effects of Alcohol upon the Muscles.**—We have learned that muscular fibres are composed of living matter, which acts when the muscle works. Observations show that alcohol has the effect to paralyze living cells. Its injurious influence

upon muscular fibres is, in part at least, due to the same cause. The weak and helpless condition of a man who is deeply intoxicated is evidently the result of very profound poisoning.

358. **Alcohol and Muscular Degeneration.** — When used for a long time, alcoholic drinks, particularly the stronger liquors, cause the muscles to become pale, weak, and flabby. Sometimes their natural structure is changed to fat. This is one cause of the dragging gait and "chap-fallen" countenance of an old drunkard. The heart and the muscular walls of the blood-vessels apparently undergo this destructive change more rapidly than other muscular structures. Intemperate men often die from heart failure and apoplexy. The notorious prize-fighter Sullivan became a physical wreck through alcohol.

359. **Alcohol and Strength.** — Scientific investigation has shown that the general supposition that alcohol gives strength is an error. Alcohol actually lessens muscular strength. A man who is exhausted with labor takes a glass of liquor and feels refreshed, but he has really gained no strength. He thinks himself stronger, because the alcohol has benumbed the nerves which tell him of his true condition. Real strength can be increased only by rest or by taking food. As we have elsewhere learned, alcohol is in no proper sense a food. It is properly compared to a whip. A man who is exhausted may force himself to further effort by taking alcohol, just as a whip would excite a horse under the same circumstances; but the extra effort is a draft on his future strength which will be felt sooner or later.

The late Dr. Parkes, of England, an eminent sanitary authority, made many experiments to determine the re-

lation of alcohol to working ability, having in his mind the "grog ration" of the British army, of which he was the chief sanitary officer. His conclusion was most decided that alcoholic drinks in any appreciable amount materially lessen a man's ability to endure severe muscular exercise. He observed that a laboring-man, after taking whiskey, felt as though he could do more work than without it, but when he undertook the task he was unable to do as much. General Lord Wolseley, commander-in-chief of the English army, cut off the "grog ration" during the war in Egypt, prohibiting the use of liquor among the soldiers, and with such good results that he adopted the same practice during the subsequent war in the Soudan, and allowed no liquor to be sold within many miles of his camp. He testifies that this course resulted in saving an immense amount of sickness among the troops.

Recently (1893) the writer undertook a series of experiments for the purpose of determining the influence of alcohol upon muscular strength. The subject chosen for the experiment was a young man about twenty years of age, who had never been addicted to the use of alcoholic drinks in any form. This young man's strength was tested by means of an instrument which is capable of recording successively the strength of each group of muscles in the body. The sum of all the tests represents the entire strength of the body. In this case the total strength of the young man upon whom the experiment was made was found to be equivalent to a lifting power of 4881 pounds. This amount represents the successive lifts made by the different groups of muscles in the young man's body. After giving two ounces of whiskey, the strength of each group of muscles was again

tested, when it was found that the young man's total strength was 3385 pounds, nearly 1500 pounds less. The total strength was thus diminished nearly one-third.

Under the influence of alcohol, a man often thinks his strength to be increased, but scientific observations show it to be less.

360. **Tobacco and Development.**—It has long been known that tobacco dwarfs the body and hinders the development of the mind. In France and some other European countries the use of tobacco is on this account forbidden to all students in the public schools. More recently our own Government has taken a step in the same direction, in forbidding the use of tobacco by the students of its military and naval schools. All medical authorities agree that tobacco is wholly bad for boys and young men. Is it not evident that a drug so powerful as to interfere seriously with the growth of the body must likewise seriously interfere with its proper repair and its various nutritive processes, even if used when the body has attained its growth? The harm may be less apparent in adults, but that mischief is done cannot be doubted.

361. **Tea and Coffee.**—Tea and coffee, like alcohol, relieve the sensation of weariness and exhaustion in a most remarkable manner, but do not really increase the strength. On this point Dr. Edward Smith, F.R.S., who made a very exhaustive study of the effects of tea and coffee many years ago, remarks: "They should not be taken by the young or the very feeble. *Their essential action is to waste the system or consume food, by promoting vital action which they do not support.*" And in a recent work he says that these statements "have not been disproved by any scientific researches."

The effect of coffee and similar beverages is identical with that of tea. Coca, a South American plant, the leaves of which are used in the same manner as tea, has been credited with remarkable power to sustain muscular effort; but that the apparent strength afforded is *only* apparent, and really of the nature of excitement, as in the case of tea, is evident from the following description of the effects of the continued use of this drug, given by Dr. C. Hartley, an eminent South American traveller: "He [the coca-eater] is known at once by his uncertain step, his sallow complexion, his hollow, lustreless, black-rimmed eyes, deeply sunk into his head, his trembling lips, incoherent speech, and his stolid apathy."

In regard to the effect of tea upon the muscles, Dr. Smith remarks that, under the influence of tea, "there is a greater readiness for, and ease in making, muscular exertion; but if it is indulged, a greater sense of exhaustion follows."

It thus appears that tea and coffee, as well as alcohol, are deceivers, and most physicians now recognize the fact that they are capable of great mischief when freely used. Hot milk is more refreshing than tea or coffee, and is nourishing as well.

SUMMARY.

1. Regular and systematic exercise is necessary to maintain the muscles in health.
2. Muscular exercise quickens the activity of all the vital organs.
3. Training of the muscles also develops the brain and the nerves.
4. Both sides of the body should be developed equally.
5. Alcohol and tobacco cause paralysis and degeneration of the muscles, lessen muscular strength, and hinder physical development.
6. Tea and coffee increase the exhaustion from labor.

CHAPTER XXVII.

THE BRAIN AND THE NERVES.

362. **The Governing Organs of the Body.**—In a complicated structure like the human body, in which each part is dependent on many others, a special arrangement is needed to secure perfect harmony of action. For example, when a child, not knowing the properties of fire, puts its finger against a hot iron, the muscles of the arm by quickly drawing the hand away save it from serious injury. When we are exposed to excessive heat, the skin pours out the perspiration to cool us off. When we run, the lungs and heart work faster to supply oxygen to support the muscles in their increased activity. Thus the numerous workers in the body mutually assist and protect each other, and, when in health, work in most perfect harmony. This harmony of action is the result of the activity of a set of organs whose functions render them the most remarkable of all vital structures. These organs constitute the *nervous system.*

363. **Nerve Tissue.**—There are two forms of nerve tissue, viz., *nerve cells* and *nerve fibres.* Really, the nerve fibres are merely appendages to, or prolongations of, the cells. Most nerve cells send out two or three slender arms, one or more of which may be prolonged into nerve fibres, while the others connect with similar arms of other cells, or, after running out a short distance

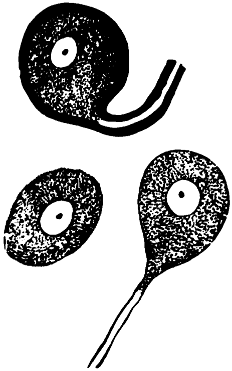

Fig. 40.—Nerve Cells.

from the cells, terminate in the spaces between them. Every nerve fibre is composed of minute threads of living matter, each of which comes from a nerve cell. The nerve fibres extend into all parts of the body.

364. **Nerve Centres.**—The nerve cells are usually found in groups. A group of nerve cells which has charge of some particular part of the body, or of some special work, is called a *ganglion* or *nerve centre*. Thus we have centres which regulate the action of the heart, sweat centres, centres to control the muscles, etc. The brain is made up of nerve centres.

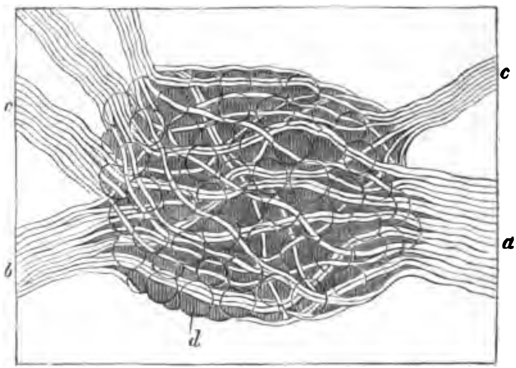

Fig. 41.—A Ganglion.
a, *b*, *c*, *c*, Nerve Fibres. *d*, Nerve Cells.

365. **Nerve Trunks.**—The little bundles of nerve fibres which pass out from the nerve centres unite to

form larger bundles, which pass off into the different parts of the body, giving off fibres to the various parts for which they are designed. These bundles of nerve fibres are termed *nerves* or *nerve trunks.* In dissecting the body of an animal, they are found as white glistening cords running everywhere among the tissues.

366. **The Brain.**—Within the skull is to be found by far the largest and most important mass of nerve tissues in the body. The entire contents of the skull constitute the brain. The average weight of the brain is about fifty ounces in men, and a few ounces less in women. With the exception of the whale and the elephant, the human brain is larger than that of any other animal.

Fig. 42.—The Brain—Side View.

The following are the weights of a few of the heaviest brains which have been weighed: Cuvier, sixty-four and a half ounces; Abercrombie, sixty-three ounces; Daniel Webster, fifty-three and a half ounces; a London bricklayer, sixty-seven ounces. An idiot's brain is smaller than an ordinary brain, sometimes weighing less than one-third as much.

367. **Coverings of the Brain.**—The brain is exceedingly delicate in structure, and, besides the protection afforded by the skull, it is covered by membranes, between which is found a small quantity of fluid which still further protects the brain from possible injury.

368. **The Cerebrum.**—The large mass of nerve tissue which fills the upper part of the skull is known as the *cerebrum.* In man this part of the brain is larger, in comparison with the remaining portion, than in any other animal. A deep fold of its covering membranes divides the cerebrum into two halves, right and left, termed *hemispheres.* The surface of the brain presents irregular ridges and furrows, forming the *convolutions.*

369. **The Cerebellum.**—Beneath the back part of the cerebrum is found the next largest mass of nerve matter in the skull, the *cerebellum,* or little brain. The form of the cerebellum is similar to that of the cerebrum. Like it, also, it is divided into a right and a left half.

370. **White and Gray Matter.**—The outside of both the cerebrum and the cerebellum is covered with layers of nerve cells to the depth of about one-sixteenth of an inch. From its color, this is known as gray matter. Underneath the gray matter the brain tissue presents a glistening white appearance. This portion is composed of fibres.

The total number of cells in the brain has been estimated to be about 1,200,000,000.

The brain is not sensitive to pain, and may sustain a severe injury without destroying its usefulness. A man had a large blasting-iron driven through his skull and through one hemisphere of his brain. The bar entered the skull below the ear, coming out at the top of the head. He recovered from the accident, and enjoyed fair health for many years, although a considerable portion of one-half of the brain had been destroyed by the accident. His intellect was not materially impaired, but his disposition seemed somewhat changed.

371. **The Central Ganglia.**—At the under side of

the cerebrum are a number of collections of nerve cells known as the *central ganglia.* The most important of these are the *optic thalamus* and the *corpus striatum.*

372. **The Medulla Oblongata.**—The extreme lower part of the brain, a rounded portion lying just above the large opening in the base of the skull, is called the *medulla oblongata.* The medulla differs from other parts of the brain in having its gray matter, or cells, in its centre, the white matter being arranged upon the outside.

Fig. 43.—Brain and Spinal Cord.

The several divisions of the brain are joined together by a portion called the *pons.*

373. **The Spinal Cord.**—The nerve substance prolonged downward from the brain through the spinal canal is called the *spinal cord.* Its length is from fifteen to seventeen inches, and its diameter is one-half an inch. Like the medulla oblongata, the central portion of the cord is composed of gray matter, the outer of white. It is protected by membranes like those which cover the brain. The cord is divided into a right and a left half, each of which is again divided into several bundles, termed *columns.*

374. **Nerves of the Brain and the Spinal Cord.**—The various parts of the brain and the spinal cord send out nerve trunks, numbering forty-three pairs in all. Twelve of these arise from the under side of the brain, and are termed *cranial nerves;* the remaining thirty-one are given off by the spinal cord, and are called *spinal nerves.* The cranial nerves leave the brain through small openings in the base of the skull. They are distributed to the face, to the organs of sense—eye, ear, nose, and mouth—and to the organs of the chest and the abdomen. The spinal nerves pass out from the spinal cord through openings in the sides of the spinal canal. Each nerve arises from the cord by two roots—one from the back part of the cord, the other from the front part. The spinal nerves are distributed to the trunk and the extremities. The brain, the spinal cord, and the nerve trunks which they give off, together constitute what is termed the *cerebro-spinal nervous system.*

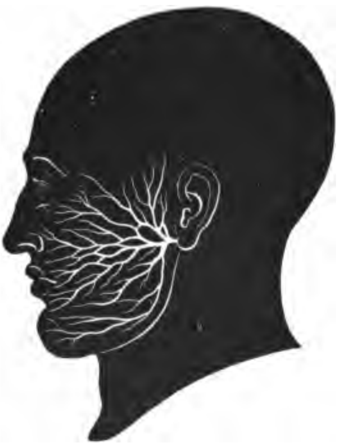

Fig. 44.—Facial Nerve.

The nerves which come from the right side of the body cross over to the opposite side in the spinal cord and at the base of the brain, so that in cases of paralysis on one side of the body the injury to the brain is generally found upon the opposite side.

375. **The Sympathetic Nervous System.**—With-

in the cavity of the body, and just in front of the spine, is placed a row of small ganglia arranged in pairs. The ganglia of each pair are connected together, and are also connected with the ganglia above and below them. Nerve branches are also sent from the different ganglia to join the cerebro-spinal nerves, and branches are received from them. A few similar ganglia are found in the cranial cavity, making in all about thirty pairs. These ganglia, and the nerves arising from them, constitute the *sympathetic nervous system.* The sympathetic nerves are chiefly distributed to the mucous membrane and to the organs concerned in nutrition—the stomach and intestines, the liver, the blood-vessels, etc. They derive their name from the fact that by their connection with the different parts of the body a close sympathy is established between its various organs.

SUMMARY.

1. The brain and the nerves control and harmonize the work of the body.
2. Two kinds of nerve tissue—*cells* and *fibres.*
3. A group of nerve cells having special work is a *nerve centre,* or *ganglion.*
4. The nerves are bundles of nerve fibres.
5. The *brain* is a collection of nerve centres—weight about three pounds.
6. The brain comprises the *cerebrum, cerebellum, central ganglia, medulla oblongata.*
7. The brain consists of gray matter—*cells ;* and white matter—*fibres.*
8. The *spinal cord* is also made up of *gray* and of *white* matter.
9. The cerebro-spinal system comprises the brain, spinal cord, twelve pairs of *cranial nerves,* and thirty-one pairs of *spinal nerves.*
10. There are thirty pairs of *sympathetic nerve centres.* The sympathetic nerves are chiefly distributed to the mucous membrane and to the organs of nutrition—heart, stomach, liver, blood-vessels, etc.

CHAPTER XXVIII.

HOW WE FEEL AND THINK.

376. **Sensory and Motor Nerves.**—It has been shown by experiment upon animals that if a nerve going to any part is cut, the application of electricity to the outer portion of the nerve causes the muscle to contract, but produces no pain; while if electricity is applied to the inner portion, pain is felt, but no muscular contraction occurs. This experiment demonstrates that nerve trunks are made up of two kinds of fibres, one carrying impressions inward, to the brain or spinal cord, and the other carrying impulses outward, to the muscles or other organs. Those nerve fibres which convey impressions inward are termed *sensory* fibres; those which transmit impulses outward are called *motor* fibres. The sensory and the motor fibres are generally bound together in the same nerve bundles. This is true of the spinal nerves, at least. Most of the cranial nerves are composed of either sensory or motor fibres exclusively.

377. **Different Kinds of Sensory Nerves.**—The nerves of sense or feeling are not all alike, for we experience many different kinds of sensations. Hearing, seeing, smelling, tasting, and feeling are all special kinds of sensation. We are also able to distinguish heat and cold, and to determine the weight of objects. Besides these special sensations, we have a number of general sensations, such as pain, fatigue, hunger, thirst, nausea,

the desire for air, etc. For each of these different kinds of sensation there is in the brain a special group of cells which has charge of that particular sense. From each special group of cells nerves go out to the various parts of the body, or to some particular part of it, as the eye, the ear, or the nose; and it is through these nerves that the various impressions which give rise to sensations are received. We shall learn more of the nerves of special sense in a future chapter.

378. **Different Kinds of Motor Nerves.** — The nerves of work, or motor nerves, also differ greatly in the kind of work which they control. This is due to the fact that they are connected with different groups of cells in the brain, each of which has charge of some particular organ or class of organs. Thus, one group of cells and its nerves control the muscles; another, the heart; another, the stomach. So, also, the liver, the lungs, the kidneys, and all other important organs in the body have each their controlling centres and nerves. Such acts as coughing, sneezing, vomiting, etc., are under control of certain groups of cells in the brain, by which they are induced. A very important set of nerves of this class are known as *vaso-motor* nerves. These nerves are distributed to the heart and the blood-vessels. They control the circulation, by regulating the size of the small blood-vessels, causing their muscular walls to contract or dilate as the tissues may need less blood or more. Blanching and blushing of the skin are due to the action of these nerves and their nerve centres.

379. **Essential Nature of the Brain.**—Essentially a brain is simply a collection of nerve cells, which receive impressions through one set of nerve fibres, and send out impulses through another. Some lower animals

have no brain, or we might say, perhaps, have many brains, since they have numerous groups of nerve cells placed in various parts of the body. When we touch the finger to a hot surface, the sensory nerve fibres in the finger transmit a painful impression to certain cells in the brain, which are set apart to receive such impressions. These, in turn, send an impulse to other cells, from which nerve fibres are distributed to the muscles controlling the arm. These cells send out an impulse to the proper muscles, which are thus made to contract, and the hand is drawn away. Thus we have special cells to *receive* impressions, or *sensory* cells, which give rise to sensory fibres, and special cells to *send out* impulses, or *motor* cells, from which arise motor fibres.

380. **How Nerves Conduct.**—The exact manner in which nerves conduct impressions is not easy to comprehend. The process may be roughly compared to the action which passes along a row of bricks set on end, and such a distance apart that when a brick at one end of the line is made to fall over it will strike the next, which in turn will fall against the next, and so on until all have fallen. The impulse given to the first brick will be transmitted through the intervening bricks to the last, no matter how great the length of the line. If we imagine the line of bricks to be a nerve fibre, one end terminating in the skin, while the other is connected to a cell in the brain, we may form a rude conception of how an impression may be conducted along the living particles composing a nerve. We can also imagine how a cell may, on receiving an impression through a nerve fibre, start it off to another cell over another nerve filament. Nerve force travels only on nerve fibres.

381. **Nerve Force or Energy.**—A slight nervous

impression, as a sudden noise, or even simply tickling the skin, may cause very vigorous muscular action. To explain this, let us return to our illustration. We may suppose that the last brick, when it falls, releases a spring which has been set as a boy sets a steel-trap for a rat, and which in action manifests much more force than was required to spring it. It requires but a small touch to release the spring, although when it acts it exerts a great amount of force. The cells of the brain and the spinal cord, as well as the muscles, are constantly storing up energy, to be released as thought or action when the proper stimulus comes.

382. **How long it takes to Feel.**—When the hand comes in contact with a hot surface, we seem to feel the heat instantaneously; but careful experiments, which have been made upon animals and upon human beings, show that a little time elapses between the instant of contact and the recognition of the sensation. In other words, a certain time is required for the sensation to travel over the sensory nerve to the centre of the brain or the spinal cord. A certain additional time is also needed for the impulse to travel from the nerve centre to the muscles, to cause them to contract. Experiments show that the nerve force travels at the rate of about one hundred feet a second. Thus a whale one hundred feet long would not feel a harpoon thrust into his tail until a second had passed; and another second would elapse before he could begin to move the injured member.

383. **Reflex Action.**—When sensation gives rise to motion, as when the finger is withdrawn from a candle-flame, the action is said to be reflex, because the impression made at the ends of the nerves of the skin is carried to the nerve centre having charge of the part, and

reflected back as an impulsė which causes the muscles to contract and withdraw the hand. This action requires no conscious effort of the will. A great share of the movements of the body are reflex acts. When we look on an object and then put out the hand to take it, the action is really a reflex of an impression received through the eye; and so with each of the senses. Many reflex acts are performed without voluntary effort, as breathing, winking, swallowing, talking, and vomiting. This is indeed a great blessing to us. By means of this admirable arrangement the mind is relieved of a great amount of routine work.

Somnambulism, or sleep-walking, is a reflex act of a very high order. Sleep-walkers will frequently perform, when asleep, feats which they would find impossible, and would not even dare to undertake when awake. A sleep-walker should never be awakened when in a dangerous position.

By long practice many actions which are at first voluntary, requiring constant exercise of the will, may become reflex, as the act of walking. When a child first attempts to walk, a voluntary effort is required each time the foot is raised and put forward. After a time, however, the action becomes reflex, so that he can walk a long distance while the mind is wholly absorbed in thought, and without giving any voluntary attention to the feet and legs. The movements of the hands and fingers, in playing on the piano and other musical instruments, as well as the bodily movements employed in many trades, are very largely reflex. It would otherwise be impossible to attain a great degree of skill in any art or trade.

384. **Automatic Action.**—Reflex actions originate in

the impressions brought to the nerve centre by sensory nerves. Some centres are capable, under certain circumstances, of originating and sending out impulses without being excited by an impression received through the sensory nerves. These are termed *automatic centres*, and the actions which they induce are said to be *automatic.* For example, the heart of a turtle or a frog, when removed from the body, will continue to beat for hours, through impulses received from nerve cells in the heart itself. The action of the lungs, liver, stomach, and many other vital organs, is automatic.

385. **Uses of the Spinal Cord.**—It sometimes happens that a severe injury to the spine at some point causes paralysis of the parts below the seat of injury. No effort of the will can cause the muscles of the limbs to move, and no application which can be made will produce pain or sensation of any sort. A hot iron applied to the foot produces no pain, even though the flesh may be severely burned; but if we tickle the bottom of the foot, it will be jerked away by a strong contraction of the muscles, although the person will feel nothing, and may not even know that his foot has moved unless he is looking at it. The feet of a person who is sound asleep will move in the same manner when tickled. This fact shows clearly that there are in the spinal cord cells which, without the action of the brain, possess the power to send out impulses to the muscles in response to impressions received through the sensory nerves. Many reflex actions of like character, which are performed by the spinal cord alone, are constantly taking place. Indeed, the execution of reflex actions may be regarded as the chief function of the spinal cord. It also gives passage to numerous nerve

fibres which go upward to the brain from the various parts of the body, and to others which pass out from the brain to be distributed to the various organs and tissues.

386. **Uses of the Medulla Oblongata.**—This organ, which is an expansion of the upper end of the spinal cord, is, like the spinal cord, a centre for reflex and automatic actions, especially those which are of the greatest importance to the body, as *respiration*, *heart action*, and *the regulation of the blood-vessels.* It also contains nerve centres for *dilating* the pupil and for *closing* the eye, for *vomiting*, *swallowing*, *mastication*, and *suction.* The importance of this part of the nervous system is shown by the fact that the mere puncture of the brain with a needle at this point is sufficient to cause death. From this fact, the medulla has been termed the "vital knot."

387. **Uses of the Cerebellum.**—It has been found that removal of the cerebellum of birds and other animals deprives them of the power to make regular movements. Diseases of this organ in human beings produce similar results, from which it is concluded that its chief office is to regulate or co-ordinate the movements of the muscles so as to cause them to act in harmony and with precision. An intoxicated person cannot walk steadily on account of the paralyzing effect of alcohol upon the cerebellum.

388. **Uses of the Cerebrum.**—The experiment of removing the hemispheres from the brain of a frog, or other animal, has been made by physiologists for the purpose of studying the condition of an animal when deprived of these large masses of nerve tissue. The animal does not die at once, as might be expected; but, if it be a frog or a pigeon, may be kept alive for some time. It is observed, however, that a most important

change has taken place in an animal which has been treated thus. If it be a frog, it will swim when placed in water, will hop when pinched or otherwise stimulated, will creep up the side of a board on which it has been placed, when it is tilted, and will croak when its sides are stroked. Thus it appears very much like any other frog, but it seems to have no sense. If made to hop by pinching its back, it will hop into the fire as readily as elsewhere. If left alone, it will remain without stirring until it perishes. It has no power to originate impulses. It has no intelligence.

It has been observed that disease of this part of the brain in human beings impairs the intelligence, and that the larger the cerebrum in proportion to the rest of the brain, and to the whole animal, the greater the intelligence of the animal. From these facts, it is evident that the cerebrum is the organ of the mind or the intelligence.

It has recently been discovered that every part of the muscular system is represented in the gray matter covering the cerebrum. Each group of muscles has a corresponding group of cells in this portion of the brain, by which it is controlled.

389. **The Central Ganglia.**—These groups of nerve matter, located at the base of the brain, are chiefly devoted to certain reflex actions connected with sensation, which are at first performed by the cerebrum, but are by degrees passed over to these centres, so as to relieve the cerebrum, and permit it to do other and higher kinds of work. Walking, writing, piano-playing, and other acts which become reflex by long practice, are largely performed by the central ganglia. In sleep-walking these centres are active, although the higher centres may be wholly inactive. The central ganglia

may be very properly called the servants of the cerebrum, since they are always in waiting to carry out its orders, and after long education become so trained that they can do some kinds of work without the supervision of the higher centres, by this means relieving them of much labor and drudgery. The acquirement of an art or a trade consists chiefly in the training of these centres, without which manual "skill" would be impossible.

390. **Relation of Mind and Body.**—Whatever may be the real nature of the mind, the close relation of the body and the mind is too evident to be doubted. Diseases of the body affect the mind, and disorder of the mind affects the body. Even the involuntary actions of the body, as the beating of the heart, digestion, etc., are affected by the mind.

391. **Inhibition.**—Among the most interesting groups of nerve cells found in the brain are certain ones which are charged with the duty of restraining other nerve centres. For example, there is a centre which causes contraction of the small blood-vessels, the vaso-motor centre. If allowed to act freely, the blood-vessels would be strongly contracted all the time. Another centre exercises a restraining influence upon the vaso-motor centre, so that it is allowed to stimulate the vessels to contract only so much as is necessary to regulate the blood supply of the various parts of the body. The controlling centre exerts upon the acting centre the same influence as a "governor" upon a steam-engine. This action is called *inhibition*. The disposition to sneeze may be counteracted by pressing hard upon the upper lip, or rubbing upon the upper part of the nose with the thumb and finger. Coughing may be usually controlled by an effort of will. These are examples of inhibition.

There are many inhibitory centres in the brain. The most important of all are those by means of which we exercise self-control. Judgment, reason, fear, conscience, hope—all inhibit other parts of the brain which might lead us to actions which we would regret. When we are young we express our emotions without restraint, in laughing, crying, etc. When we become older we learn to control our feelings. Some persons do not learn this as they should, and make much trouble for themselves and others by their lack of self-control, giving way to fits of anger or grief in a most reckless manner. One of the most important uses of the front part of the large brain is to inhibit the action of other parts of the nervous system.

392. **Habit.**—When once an act has been performed, it is easier to perform the same act the second time; and each time the act is repeated it is done with a little greater ease, until after a time it is done without thought and without any effort of the mind, because the central ganglia have been educated to do it. The act has now become habitual, and we say it is a *habit.*

We form habits in relation to mental and moral acts, as well as in respect to merely mechanical acts, as walking, eating, etc., and in precisely the same way. Whenever we do a wrong act, it becomes easier to do the same again, and our power of resisting temptation is lessened with each repetition of the act. On the other hand, our resolution and ability to resist evil are strengthened each time we overcome a temptation to do wrong. Hence the importance of cultivating right habits. Consider, when tempted to do a wrong act, that it will leave behind it an effect upon the brain which may not be easily effaced. We should cultivate good thoughts, good

habits, good manners, until they become second nature, or habitual.

393. **Memory.**—The faculty of recalling past mental impressions is *memory*. Memory is a property of nerve cells. Some objects give off light in the dark after having been exposed to the sunlight. This property is termed phosphorescence. In the same way nerve cells may give off or revive the impressions which they have received. Memory is a sort of organic phosphorescence. The thing most essential for a good memory is that the first impression shall be strong. For this it is necessary that the attention should be concentrated upon the thing to be memorized, and the mind kept free from all other ideas until it is fully comprehended and thoroughly impressed upon the mind. Memory may be greatly improved by cultivation. It forms the basis of habit.

SUMMARY.

1. Two kinds of nerves—*sensory* and *motor*.
2. Sensory nerves—general sensation, as *pain*, *hunger*, *fatigue*, *thirst*, etc., and special sensation, as *hearing*, *sight*, *taste*, *smell*, *touch*.
3. Motor nerves control the *muscles*, *lungs*, *liver*, *stomach*, *coughing*, *sneezing*, *vomiting*, etc.
4. A brain receives impressions and sends out impulses.
5. *Nerve force* is stored in nerve cells; it travels at the rate of about one hundred feet per second. To feel requires perceptible time.
6. Most acts, even voluntary acts, are *reflex*.
7. The *automatic centres* act independently of sensation or volition.
8. The spinal cord both transmits and originates impulses, and gives rise to reflex acts.
9. The *medulla oblongata* is a reflex and an automatic centre—controls heart, regulates blood-vessels, respiration, vomiting, swallowing, etc.
10. The repetition of an act renders its performance easier; when it becomes *automatic* it is a fixed *habit*.
11. *Memory* is a property of nerve cells. It may be improved by cultivation.

CHAPTER XXIX.

HYGIENE OF THE BRAIN AND THE NERVES.

394. **Mental Exercise Necessary.** — Exercise is quite as essential to the health of the brain and the nerves as to that of the muscles. A brain which is not used rapidly loses its ability to do mental work. Mental exercise develops mental strength and capacity, just as muscular exercise develops muscular strength and skill. That brain work is healthful is shown by the fact that great thinkers, scholars, philosophers, and other brain workers are the longest lived of all classes of men.

Brain exercise, to be healthful, must be properly regulated. Too much study is harmful, and weakens rather than strengthens the brain. Each brain has only a certain number of brain cells, and is capable of holding only a certain amount of knowledge. An eminent physiologist estimates that the most retentive memory cannot acquire more than two hundred thousand distinct facts, and a much smaller number is probably the limit of ordinary minds. When the full capacity of a brain is reached, new facts are received only by crowding others out. Hence, we should exercise care in selecting what we undertake to store up in the mind, so that it may not be like a neglected garret, full of all sorts of rubbish, without order, and of little practical value. Never try to learn or remember what is not worth learning or remembering, as it will interfere with the retention in the memory of something of real value.

395. **How to Study.**—Proper study makes the mind stronger, and able to do a larger amount of mental work, just as proper exercise strengthens the muscles. There is a right way and a wrong way of studying. "Cramming," that is, hastily crowding facts into the brain simply by an effort of the memory, is exceedingly detrimental to the health of the mind. Careless and indifferent study is of no value, and injures the mind. Students should always endeavor to discover the principles involved in what they study, so that they may not be obliged to depend upon the mere memory of facts. Those who learn by mere repetition, as do parrots, never become learned and do not acquire real culture.

It is not well to study when the brain is weary. The impressions then made upon the brain are very slight, and soon become indistinct, so that what is learned is quickly forgotten. Two or three hours are as much time as most students should spend at hard study without at least a short rest. A half-hour's exercise in the open air will renew, to a remarkable degree, the retentive power of the brain and the capacity for study, when the mind is weary with continuous work. In school study, the most important thing to be gained is mental culture and discipline—the ability to use the mind in the practical affairs of every-day life, and in acquiring useful knowledge.

396. **How to Remember.**—A few hints upon the art of not forgetting may be of great use to students: 1. Give attention. Concentrate the mind intensely upon the subject to be learned. "Mind-wandering" is the greatest of all obstacles to effective study. Many persons can remember almost nothing on account of this infirmity. Compel the mind to attend closely to the one thing in

hand. 2. Study carefully the relations and associations, all the parts and properties, of the thing to be memorized. 3. Link the new fact to something already so familiar to the mind that it cannot be easily forgotten. If it is a new word, associate it with a familiar word of similar sound or meaning, or even one of opposite meaning. The mere act of making such an association serves to impress the word upon the mind. 4. If it is a list of words to be committed to memory, do not endeavor to force them upon the mind by mere repetition, but weave them into a chain of words so arranged that each word suggests the one to follow.

In making such a list one commits it to memory by noticing the relations of similarity or contrast between each word and the word following it. By this method a thousand words can be carried in the memory as easily as ten. The memory is strengthened by this method of memorizing, while it is often weakened by the ordinary method of learning by rote.

397. **Mental Worry.**—Worry is in the highest degree detrimental to the health of the brain and nerves. A brain which will endure without injury a vast amount of healthful work will rapidly fail under the influence of constant worriment and perplexity. The anxiety and wearing mental excitement of the gambler or the stock-broker doom him to an early decline of his mental faculties, or to a premature grave. *Brain worry* destroys many ; *brain work* injures very few.

398. **Evils of Excitement.**—Violent mental excitement exhausts the brain and the nervous system much more than ordinary mental or nervous action. Such emotions as fear, hatred, jealousy, envy, anger, and all of the passions, as well as excessive mirth and joy, are

extremely exhausting to the nervous system, and some are dangerous to life. Exciting amusements, and the reading of exciting books, especially those of a sentimental character, are unfavorable to healthy mental growth. Too much reading of any sort is injurious. One book worth reading, carefully read and mastered, is worth a hundred carelessly and hastily run through. Hasty and promiscuous reading weakens the mind and destroys the taste for solid and wholesome books.

399. **Sleep.**—The brain, like the muscles, when used continuously for some hours, or when violently exercised even for a short time, becomes clogged with worn-out particles from the waste of its tissues, and its nervous energy becomes exhausted. When the waste has continued as long as is safe or proper, nature warns us of the fact by a sensation of mental weariness or drowsiness. During sleep the waste matters are removed, and a new store of nervous energy is accumulated by the cells of the brain and other nerve centres. Loss of sleep produces irritability of temper and loss of mental vigor. The body requires at least seven or eight hours of sleep daily. Children and young persons require more sleep than older persons.

400. **Nerve Tone.**—When the nerve cells contain a good store of nervous energy they are said to be in good *tone*. Anything which impairs the bodily health lowers the tone of the nerves. Lowered nerve tone involves impairment of the mental tone, and produces a corresponding effect upon the moral tone.

401. **Self-Control.**—This is a faculty which is possessed in different degrees by different persons. It should be cultivated by all as one of the most essential of requirements. It grows, like the other faculties, with use, and

weakens with disuse. The usefulness of thousands of persons is hopelessly wrecked by lack of self-control. By the development and exercise of this faculty the mind may be kept free from evil thoughts. The hasty, profane, or unclean word will be checked before it is spoken, and the appetites and passions which lead so many to ruin will be held in subjection.

A brain may be compared to a picture-gallery, in which hang the portraits of a long line of ancestors reaching back to Adam. Time may have effaced their features, but the outlines are distinct, some shapely and beautiful, others deformed and hideous. It is well for us to remember that our own portraits, sketched true to life by an artist more exact than the most skilful painter, may hang in the mind-galleries of the generations to come.

402. **Food and Brains.**—The brain, like the rest of the body, is made of what we eat. An old German proverb runs, "As a man eateth, so is he." This is especially true of the brain. If the blood is filled with pungent spices and irritating condiments, it will excite the nerves, causing irritability and nervousness. Excessive use of animal food causes similar results, producing undue nervous excitability, especially of the lower faculties of the mind. The food must contain an abundance of those elements which build up the nervous system, particularly the phosphates and the albuminous elements. Such whole-grain preparations as Graham or entire wheat flour, also peas, beans, eggs, and milk, contain phosphates in good proportion.

Students should by no means conceive the idea that they need little food. The brain needs for its support an abundance of the best food; but eating too much

must be carefully avoided, since excess clogs the brain as well as the other tissues. Overeating is a common cause of mental dulness. Students, above all others, need to attend closely to the rules of diet. Much of the headache, dulness, and mental confusion which are attributed to overstudy or mental incapacity are really due to imperfect digestion, which furnishes the brain with poor material, and poisons it with the products of indigestion.

403. **Necessity for Muscular Exercise.**—For the preservation of good mental health the general health must be maintained by attention to all the laws of hygiene. Muscular exercise is especially of the greatest importance to all classes of brain workers. The neglect of muscular exercise is much oftener responsible for the break-down of students and professional men than too much mental work. The average student requires at least one or two hours of vigorous exercise daily. It will not do to neglect daily exercise, and then endeavor to atone for it by devoting a week once or twice a year to violent exertions. This sort of spasmodic exercise is often more harmful than beneficial. Exercise, like sleep and food, should be taken regularly and daily.

SUMMARY.

1. Exercise of brain and nerves is essential to mental and nervous health.
2. Brain capacity, being limited, should not be wasted.
3. Proper study strengthens the brain; "cramming" weakens it.
4. Mental work is healthful; worry is exhausting.
5. Prolonged mental or nervous excitement is exhausting.
6. Eight hours' sleep are required. Children need more.
7. Inhibition is an important function of the brain, especially in regard to moral acts.
8. Stimulating and unwholesome foods injure the brain.
9. Brain workers require physical exercise daily.

CHAPTER XXX.

EFFECTS OF ALCOHOL UPON THE BRAIN AND THE NERVES.

As we have elsewhere learned, alcohol, when brought in contact with any of the delicate tissues of the body, produces serious results; but it is in its effects upon the nervous system that the mischievous character of this fascinating drug is most clearly seen. In small doses alcohol seems to excite mental and nervous activity; but the close observer will note that under the influence of alcohol, even in very small doses, the controlling power of the reason and the will are to some degree lessened. Under the influence of liquor, even to a slight degree, a man will speak with less care, precision, and prudence than when free from the drug.

404. **The Whiskey Flush.**—One of the first effects observed after alcohol has been taken is flushing of the face. Not only the face and other parts of the skin, but the whole body, the brain, the muscles, all the internal organs, are flushed. This is due to the paralyzing influence of the drug upon the vaso-motor centres—those which govern the size of the small blood-vessels. The vessels, being no longer under control, relax and fill with blood; and if the body is exposed to cold, the temperature soon falls below the standard of health, in consequence of the presence of so large a volume of blood at the surface of the body.

A little later, the centres which are involved in reflex

action and in the regulation of muscular movements become affected; the underlip falls, the tongue becomes thick, the limbs totter, and the walk is irregular. Presently the mind begins to exhibit the baneful effects of the poison. The higher faculties of the brain lose their control over the lower faculties. The will is paralyzed. The animal nature, freed from restraint, sometimes takes full possession of the individual, and the man becomes, for the time being, a brute. Still the drug continues its poisonous influence until all the faculties are benumbed and paralyzed. The drinker is now insensible, and is said to be "dead drunk."

A person who is dead drunk is but a hand's-breadth removed from actual death. All the vital functions are nearly paralyzed. Any small circumstance, as exposure to a little extra cold or heat, may be sufficient to snuff out the flickering flame of life. It is asserted by some authorities that a man who has once been dead drunk never fully recovers from the effects. The idea that alcohol protects a person from any of the causes of disease is a very grave and mischievous error. It undoubtedly increases the liability to disease of nearly every sort, and greatly increases the fatality of most diseases.

The alcohol gradually escapes from the body through the lungs, skin, and other eliminative organs, and, after a few hours, sensibility and consciousness return; but some time elapses before the individual fully recovers from the effects of the poisoning to which he has been subjected. The nerve tone is greatly lowered, the hands tremble, the head aches, the mind is confused, and there is so great depression of spirits that the drinker feels compelled to resort again to alcohol to relieve his sufferings, and thus the habit is continued.

405. **Alcoholic Nervousness.**—The habitual use of alcohol, even in quantities not large enough to cause intoxication, often produces permanent results similar to those following a single large dose. By degrees the nerve centres lose their tone, and the hand becomes habitually unsteady, except when the system is under the influence of liquor. The flushed face, red eyes and nose, exhibit the paralyzed condition of the vaso-motor nerves. The mind becomes less acute and active, and the character is changed for the worse.

406. **Alcoholic Insomnia (Sleeplessness).** — The blood-vessels of the brain, under the influence of alcohol, become relaxed, as do those of the face. The excess of blood in the brain keeps up an unnatural, though inefficient, activity, and the man who at first took his evening dram as a "nightcap," to make him sleep, after a time finds himself wholly unable to sleep; or, if he falls asleep, he is constantly awakened by frightful and distressing dreams.

407. **Delirium Tremens.**—The hard drinker sometimes so completely exhausts his nervous system that reason becomes temporarily dethroned. The hobgoblins, grinning fiends, and hideous reptiles which formerly haunted his restless, unrefreshing sleep, take possession of his waking hours. Everything about him seems alive. Each familiar object appears to him like a furious beast ready to seize upon him. His most trusted friends are transformed into enemies. His countenance, haggard with disease and want of sleep, with staring, bloodshot eyes starting from their sockets, glancing this way and that as new and still more frightful shapes arise, depicts in every line a horror indescribable, while every muscle quivers and every nerve fibre seems a thread of fire.

One glimpse of a victim of *delirium tremens* would be a better temperance lesson than any pen could write. Not infrequently the poor victim's sufferings end only with death—a death of shame.

408. **Changes in Nerve Cells and Fibres produced by Alcohol.**—The first effects of alcoholic drinks, like those of most other poisons, are quite readily recovered from if the doses are small and not often repeated; but when long used, or when used in large doses, and in many persons even in doses called moderate, the nutrition of the nerve structures is impaired. The brain, receiving one-fifth of all the blood in the body, receives with its large blood supply an equally large proportion of the alcohol which may be taken, and hence is among the first of all the organs of the body to suffer from its effects. The connective tissue which holds its delicate cells and fibres together is stimulated by the irritation of the alcohol to abnormal growth, and afterwards contracts upon them, thus crippling or destroying them.

Paralysis of various organs, and even of the whole body, is a not uncommon result of the degeneration of nerve structures caused by alcohol. The use of strong liquors is the frequent cause of *locomotor ataxia*—a disease which is seldom cured. The victim of this malady walks all the time much like a man who is intoxicated. His nerve centres have been temporarily paralyzed so many times by alcohol that they have finally been damaged to such a degree that they remain permanently paralyzed. At first only the legs are affected. By-and-by the hands become equally unsteady, so that the afflicted person cannot feed himself. If the miserable man lives long enough, he finally becomes unable to

swallow. His whole body is paralyzed, and he dies a most horrible death.

Sometimes the nerve structures undergo a change in which their essential parts are replaced by fat, resulting in various forms of paralysis. By its destructive effects upon the nervous system, which controls and regulates the entire body, the mischievous influence of alcohol is made universal in the body, aside from its direct effects upon other tissues, which have been studied elsewhere.

409. **Alcohol not a Stimulant.**—If by a stimulant we mean something that gives strength, then alcohol cannot be considered a stimulant. It certainly does not strengthen either the nerves or the muscles. Its real effect is that of a narcotic; it benumbs and paralyzes. It produces a sensation of strength by destroying the sensation of fatigue, but it does not give strength. One might as well inhale ether or chloroform, or take strychnia or arsenic, for the purpose of gaining strength, as to take alcohol.

410. **Effects of Alcohol upon the Character.**—Alcohol lowers moral tone as well as nerve and mental tone. The moral sensibilities of the drunkard are blunted. When under its influence sin does not seem so sinful, crime so criminal, nor dishonor so dishonorable as before, and his weakened will leaves the victim of intemperance an easy prey to vice and crime of every sort. Men go down the scale by degrees: first, the social glass occasionally; then the regular dram; then the loss of moral sense, self-respect, and respect for the rights of others; and, finally, the commission of some dreadful crime under the influence of liquor. The loss of will-power, of self-control, caused by so often yield-

ing to temptation, as well as by the direct influence of the drug, is the great obstacle that stands in the way of the reformation of the drunkard and the victims of all vice-drugs.

411. **The Alcohol Legacy.**—Not the least of the many grave charges which science brings against the alcohol habit is the fact that its effects do not stop with the user; they are transmitted to his innocent children. A child may inherit from a drunken parent an almost irresistible appetite for drink, together with a weakened will, so that it will almost certainly become a drunkard.

This is not, however, the most common inherited effect of the liquor habit. It has been observed by physicians that the children of drinking parents inherit a tendency to *epilepsy*, or "falling-sickness," to *idiocy*, and especially to *insanity*. Dr. Hurd, the late superintendent of the Eastern Michigan Insane Asylum, has made a careful investigation of this subject, and finds that, in the cases of a very large proportion of the insane, one or both parents were given to drink. The "insane temperament" is often transmitted, even when the parent has shown no symptom of insanity except when under the influence of liquor.

The reason for this is plain when we reflect that the different stages of the mental disturbance which results from taking a full dose of alcohol correspond exactly to the different phases of insanity. In fact, a man under the influence of liquor may be said to be insane just to the extent of the influence of the drug upon him. After many repetitions of the intoxication, an impression is made upon the brain and nervous system which may be inherited by a child as a tendency to insanity that may develop at any time of life.

412. **Moderate Drinking Dangerous.**—Most of the effects which have been described are those which result from the use of alcohol in quite large quantities. Nevertheless, it cannot be denied that while alcohol may sometimes be used in small quantities for many years without producing very noticeable effects, there are very few persons indeed who can use it for any great length of time without increasing the dose to an amount which is harmful to a degree at once apparent. The advocates of moderate drinking must admit that alcohol is not naturally demanded by the system, and that its use is both unnecessary and dangerous, even for those who desire to restrict its use to a moderate allowance. It possesses no good property which we might not easily do without, or find in less dangerous substances, and involves many and grave possibilities of evil.

413. **The Effects of Tobacco upon the Nerves.**—Every one is familiar with the tremulous hand of the smoker. Many persons whose business requires a steady hand have been compelled to renounce the use of tobacco on this account. When the hand trembles, the difficulty is not in the hand, but in the nerve centres which control the muscles of the hand. If we examine the pulse of such a person, we often find that the heart trembles as well as the hand; that is, it does not beat regularly, is subject to palpitations, and sometimes to paroxysms of pain. (See cut on page 121.) All this comes from the same cause, the poisonous influence of nicotine upon the nerve cells.

The wide prevalence of tobacco using is unquestionably one of the causes of the great increase of nervous disorders among men. Various forms of nervous disease have been traced directly to the use of tobacco, and

at the present time the most scientific physicians condemn it as a harmful practice.

The moral effects of tobacco using are certainly bad. A boy who smokes or chews associates with other boys who do likewise, among whom he is sure to find companions of the worst habits. Tobacco using also leads to the liquor habit, by creating nervous symptoms from which alcoholic drinks seem to give temporary relief.

414. **Tobacco and the Brain.**—Some years ago an investigation was made in the public schools of France, which resulted in the prohibition of the use of tobacco by all students in the schools. Dr. Seaver, of Yale University, has shown that students who use tobacco are inferior to those who do not, both physically and mentally. The sale of tobacco to boys has been prohibited by law in several States of this country. The bad effects of tobacco using are so well recognized in Switzerland that very strict laws have been made against it. A boy found smoking upon a street in that country is promptly arrested by the police.

415. **Cigarettes.**—The use of cigarettes by boys and young men, which is becoming so common, is worthy of strongest condemnation. This method of taking tobacco is the most pernicious of all. Deaths from cigarette smoking are frequently reported. The writer has met many cases in which young men have been ruined mentally, as well as physically, by the use of cigarettes.

416. **Hereditary Effects of Tobacco Using.**—While the hereditary effects of tobacco using are not so apparent as those which follow the use of alcohol, there is good ground for believing that the free use of tobacco may so injure the nervous system that children may suffer through inheriting a tendency to nervous diseases.

There is no excuse for the use of tobacco which will not also apply equally well to the use of opium, alcohol, or any other narcotic.

417. **The Opium Habit.**—The increase in the use of opium has been so enormous within the last few years as very justly to excite alarm among all who are interested in the welfare of the race. Of all drugs, opium is perhaps the most fascinating, and the habit of using it the most difficult to overcome. The ease and comfort afforded by it, when painful disease is present, allures the victim into the acquirement of a habit which ultimately ceases to give pleasure, or even to relieve suffering, and renders its victim most miserable.

The opium habit is usually acquired by the use of the drug to relieve pain, either in the form of opium itself or any one of its various preparations, the most common of which are *morphia*, *laudanum*, and *paregoric*. Often it is first taken by prescription of a physician, and is continued by the patient. Many patent medicines contain opium, as do most of the cough mixtures, "soothing syrups," etc. These nostrums are very dangerous, and should never be used.

Opium in any form should never be used without the advice of a reliable physician, who appreciates the dangers from the use of the drug, as well as the possible benefits to be derived from it.

Opium, when habitually used, ruins the nervous system and the mental and moral faculties. Self-control and self-respect are lost. Reputation, honor, friends, wealth—everything is sacrificed for the gratification of the artificial appetite which has been established. The victim finds that, when he attempts to discontinue its use, he is overwhelmed with untold sufferings the mo-

ment the influence of the drug is gone. Prostrated with indescribable weakness and faintness, distracted with excruciating pain, it is no wonder that he returns again to the only source of immediate relief. These miserable beings are greatly to be pitied, and their horrible experience should be a warning to those who are yet free from the snare.

Any one who has ever seen the besotted opium-smoker indulging his vice in one of the horrible opium dens of China or San Francisco, will be surprised to learn that this dreadful practice is being adopted by Americans and Europeans. In both New York and London these dens are frequented by a considerable number of persons who have acquired the practice since its introduction into these cities by the Chinese, and the number is said to be increasing.

418. **Chloral and Kindred Drugs.**—Hydrate of chloral, bromide of potassium, and other sleep-producing and nerve-benumbing drugs, are very largely used in patent medicines, and not infrequently by persons who have learned their use from popular medical works. It ought to be generally known that the sleep produced by these drugs is not healthful, refreshing slumber, but is what an eminent physician has well called "poison sleep,"—a state in which the sensibilities are benumbed into unconsciousness, but in which the natural processes of repair and storing up of nervous and vital energy are not properly performed.

Narcotic drugs relieve pain, but do not remove its causes. A pain of which we are made unconscious by a stupefying drug is still present in nearly full force, so far as the system is concerned, although we are not conscious of it; just as a man whose limb is amputated

while he is insensible from chloroform feels no pain, although the tissues are hurt just as much as if he did. Any drug of this class, used habitually, causes serious disorders, and generally disturbs the digestion, as well as nearly every other vital process in the body.

419. **Tea and Coffee.**—By far the most common cause of "nervous" and "sick" headaches, ailments which tea is supposed to be most potent in relieving, is the use of this very beverage. Much of the nervousness, neuralgia, nervous dyspepsia, and sleeplessness among women is recognized by observing physicians to be due to the use of tea and coffee.

There are many, even among physicians, who are ready to apologize for the use of tea and coffee, and undoubtedly some persons use these drugs in quantities so moderate that no serious effects are felt; but the fact that they are potent for harm, and that an immense amount of injury is done by their use, ought to be generally known. We may well dispense with the use of articles which, under the deceptive guise of "the cups that cheer, and not inebriate," have captivated nearly the entire civilized world.

Dr. Nansen, the eminent Arctic traveller, states that the Esquimaux of the east coast of Greenland, being unable to obtain alcoholic drinks, which are strictly forbidden by the Danish Government, use strong coffee in large quantities and become deeply intoxicated by it, and with most disastrous effects. Dr. Nansen asserts that coffee is a great curse to the Esquimaux.

420. **Cocaine.**—This new vice-drug is most deadly and destructive in its effects. The immediate effects of its use are similar to those of opium, but more transient. The health, physical and mental, rapidly succumbs to its

influence, and insanity and death speedily follow. The general use of this drug in diseases of the eye and the nose has led many to become victims of its fascinating influence. The cocaine-habit is more difficult to overcome than the use of either opium or alcohol.

421. **The Poison-Habit.**—The use of alcohol, tobacco, opium, cocaine, and various other kindred drugs produces in the user a morbid condition in which there is an abnormal craving for some agent which will benumb sensibility, or temporarily produce a pleasurable sensation. This condition, when once established, is exceedingly difficult to overcome, and leads the unfortunate victim of the poison-habit to seize upon any drug which will afford him temporary relief from the horrible nervousness to which he is a constant prey, or which will serve as a nerve-tickler to give him some sensation which habit has led him to consider pleasurable. It is for this reason that we seldom find the victim of the poison-habit using only a single drug. The man who is addicted to the use of liquor almost invariably uses tobacco also, and not infrequently opium is added to the twin poisons mentioned. Women who drink strong tea and coffee not infrequently find it necessary to resort to the use of chloral and opium to relieve the nervousness produced by these drugs; and it is an easy step from tea and coffee inebriation to the use of wine and brandy when occasion requires an extra strong "pick-me-up."

By the use of these drugs the nutrition of the body becomes so much impaired that its very structure is changed. The nervous system is particularly subject to these functional disturbances and structural changes. The brain, the organ of the mind, receiving a large proportion of all the blood of the body, is especially affected

by these poisonous drugs. The character of the individual is seriously modified and impaired. The use of alcohol, for example, weakens the will of the user. The tobacco devotee, as a rule, through his habit becomes selfish, and loses his nice sense of propriety and cleanliness. The opium user becomes untruthful, and in many other respects unreliable.

The growth of the poison-habit in this and other civilized countries is coming to be one of the greatest of all the scourges of civilization. It is not safe to trifle with any of these drugs, since the habit of their use, while easily acquired, often fastens itself upon the victim with such unyielding tenacity that escape becomes impossible. Thousands of boys, and sometimes girls also, have been ruined by the habit of cigarette smoking. It has been recently shown that the manufacturers of cigarettes not infrequently put into them drugs more fascinating and poisonous than tobacco, thus securely fastening their victims to the use of their own particular brand.

SUMMARY.

1. Alcohol lessens the inhibitory power of the brain, and hence weakens the will and injures the character.
2. Hereditary effects of alcohol—insanity, nervous diseases, and the liquor habit.
3. Tobacco lessens mental vigor and occasions many nervous disorders.
4. Strong tea and coffee cause nervous disease.
5. Opium and chloral destroy both mind and body.
6. Cocaine is the most deadly and fascinating of all vice-drugs.
7. The poison-habit produces effects which are not only destructive to the individual, but may be transmitted by heredity.

CHAPTER XXXI.

THE SPECIAL SENSES.—THE SENSE OF TOUCH.

422. **What is Sensation?**—Sensation is the result of a change in the condition of a sensitive part. When an object is brought into contact with the skin, it is at first distinctly felt; but if the contact is maintained for some time, we cease to realize the presence of the object, and remain unconscious of its presence until it is removed.

423. **Two Kinds of Sensations.**—There are two kinds of sensations: 1. Those which inform us concerning conditions within the body, as *pain*, *hunger*, *thirst*, *satiety*, *nausea*, *giddiness*, *fatigue*, and *drowsiness*, which are called *general sensations*. 2. Those by means of which we obtain a knowledge of the properties of external objects, as *sight*, *hearing*, *smell*, *taste*, *touch*, *the sense of temperature*, and *the sense of weight*, which are called the *special senses*.

Pain is produced by injury to the tissues, and by excessive stimulation of any of the senses, even those which are ordinarily most pleasurable. A very bright light pains the eyes; a very loud sound is painful to the ears. Pain is one of the most useful of all sensations. It often preserves the body from serious injury, acting as a sentinel to give warning when harm is threatened.

The sense of *touch* is located in the skin, and in portions of the mucous membrane near the openings of the body. It is most acute in the ends of the fingers, the

lips, and the tip of the tongue. By its aid we are able to distinguish the form of objects, and whether they are hard or soft, rigid or elastic, etc. (See Experiment 22, page 276.)

The sense of *space*, or *locality*, is probably a modification of the sense of touch. Through its aid we are able to determine the part of the body touched by any object. There is great difference in the acuteness of this sense in different portions of the body.

By the sense of *pressure* we are able to distinguish between the weights of two objects allowed to rest upon the same spot, one immediately after the other. This sense is a modification of the sense of touch.

The delicacy of the sense of touch and of its various modifications may be greatly increased by education. In the blind it is often extraordinarily acute.

The sense of *temperature* is another so-called modification of the sense of touch, although it is probable that it requires a separate set of nerves. This sense enables us to determine the temperature of objects, or to distinguish between heat and cold. The temperature sense is largely relative, giving us an idea of the difference in temperature between the object touched and the part of the body touching it, rather than of absolute temperature. The mucous membrane is less sensitive to heat and cold than is the skin.

The *muscular sense*, or *the sense of weight*, enables us to determine the amount of exertion required in lifting and other muscular efforts. It also tells us of the rapidity with which the muscles contract, and of the position of the limbs of the body. Though probably an independent sense, and located in the muscles, the sense of weight is closely allied to that of touch.

424. **Effects of Alcohol.**—The paralyzing effect of alcohol is well shown by its influence upon the sense of touch. A few drops of alcohol applied to the end of the tongue destroy its marvellous delicacy of touch. When taken in large doses, alcohol produces as profound insensibility to pain as does ether or chloroform. It was used as an anæsthetic in surgical operations before the discovery of chloroform and ether, but its use was discontinued on account of the effect upon patients in delaying their recovery and increasing the risks of serious operations.

In some experiments recently made by the author for the purpose of ascertaining the effect of alcohol upon the nervous system, it was noticed that the sense of touch was diminished more than one-half as the result of taking two ounces of whiskey. Before taking the whiskey the subject of the experiment was able to recognize the contact of an object with the skin in one-seventh of a second. A short time after taking two ounces of whiskey the delicacy of the sense of touch was diminished to such a degree that more than twice as long was required for the recognition of the contact with the skin. The same series of experiments showed that the sense of temperature and other modifications of the sense of touch were equally diminished by alcohol.

SUMMARY.

1. The sense of *touch* is located in the skin, and in the mucous membrane near the openings of the body.
2. The senses of *space* or *locality*, of *temperature*, and of *pressure*, are closely related to the sense of touch.
3. The *muscular sense*, or *sense of weight*, resides in the muscles.
4. The delicacy of each of these senses may be greatly increased by education.
5. Alcohol benumbs the sense of touch; it is an anæsthetic.

CHAPTER XXXII.

THE SENSE OF SMELL.

THE nerves of *smell*, or the *olfactory sense*, is located in the mucous membrane of the upper portion of the nasal cavity. The ends of these nerves are bare, so that the odorous particles by which they are excited may come into immediate contact with them.

In order that the sense of smell shall be exercised, the odorous substances must be brought to the nose by the air, the mucous membrane must be moist, and the air must be drawn through the nose. When the nose is obstructed, as by a cold, the sense of smell is greatly lessened or lost. Odorous substances are smelled when held in the mouth, the odorous particles being carried through the nose by the outgoing breath. This often leads us to ascribe to substances flavors which are really odors.

425. **Acuteness of the Sense of Smell.**—The acuteness of this sense is so great in healthy persons that so small a proportion as one-millionth part of a grain of some substances may be easily detected in the air of a room.

The mucous membrane of the nose possesses general sensibility, the same as other portions of the body. Many of the sensations experienced through the nose, and commonly called odors, are those of pain rather than of smell. The inhalation of ammonia, and of most

other irritating gases, excites the nerves of pain and not the olfactory sense.

426. **Use of the Sense of Smell.**—This sense may be of service to us in determining whether substances are fit for food; it also warns us of the danger of inhaling poisonous gases. It is a noteworthy fact that among natural odors—that is, such as an uncivilized man would come in contact with—those which are offensive are connected with poisonous or unwholesome substances.

427. **Hygiene of the Sense of Smell.**—As just intimated, offensive odors are to be regarded as unwholesome. Nature has wisely placed this danger-signal at the very portal of the body, and its warning should always be promptly heeded. If disregarded, odors which are at first very offensive are soon tolerated, and after a time are no longer observed.

Strong Odors of any sort are objectionable, as they are usually produced by volatile substances which are injurious if taken into the system in any but the most minute quantities. This, also, nature hints to us in causing the most agreeable odors to become disgusting when inhaled in too concentrated a form.

The sense of smell is sometimes more or less completely lost, as the result of frequent and neglected colds, which may destroy the sense of smell by causing obstructions of the nasal passages, so that odors cannot reach the olfactory nerves, or may even destroy the nerves themselves.

428. **The Effects of Tobacco and Alcohol upon the Sense of Smell.**—The abominable habit of snuff-taking is fatal to the sense of smell. Smoking, especially cigarette-smoking, is often a cause of the loss of this useful sense. The tobacco-user is also a source of

offence to the noses of all people who do not defile themselves with the filthy weed. No one whose ideas are not greatly perverted will be willing to saturate himself with a vile-smelling drug, against which Nature seeks to protect herself by destroying his sense of smell, but which makes him a nuisance to everybody else not in the same condition as himself.

The alcohol-habit, as well as the tobacco-habit, is a means of destroying the sense of smell, exposing the user as it does to frequent colds by causing relaxation of the exposed blood-vessels so that they become easily chilled. The effect of alcohol in producing congestion of the nasal mucous membrane is indicated in a most positive manner by the redness of the face so often observed in chronic topers. The thickening of the skin of the face and the frequent enlargement of the nose commonly known as a "rum blossom" is associated with a similar thickening of the mucous membrane of the nose by which the nasal passages are closed, the delicate nerves of smell buried beneath a swollen membrane, and thus the sense of smell more or less completely obliterated.

SUMMARY.

1. The nerves of *smell* are located in the upper part of the nasal cavity.
2. Many so-called odors are really sensations of pain.
3. The object of the sense of smell is to warn us against poisonous and harmful substances.
4. The nose soon becomes accustomed to bad odors; hence, their first warning should be heeded.
5. Strong odors, even at first agreeable, may become injurious.
6. Repeated colds destroy the olfactory sense.
7. Snuff-taking and cigarette-smoking destroy the sense of smell.

CHAPTER XXXIII.

THE SENSE OF TASTE.

The nerves of *taste* are located in the sides and back of the tongue, in the soft palate, and in the upper part of the throat. There are three distinct nerves of taste, which are distributed to different parts of the tongue.

429. **The Tongue** is a muscular organ, and one of the most remarkable in the body, being capable of wonderfully rapid and varied movements. The mucous membrane which covers it presents on its upper surface many little prominences called *papillæ*, in which nerves both of taste and of touch are distributed.

430. **How and What We Taste.**—In order that a substance may be recognized by the tongue it must be soluble; that is, it must dissolve in water. Substances which will not thus dissolve have no flavor. The dissolved substances soak through the thin layer of cells covering the ends of the nerves of taste, and thus excite sensation in them.

Although we recognize a great variety of flavors, the majority of so-called tastes are combinations of tastes, odors, and impressions of touch.

The sense of taste does not seem to be equally distributed over the surface of the tongue. With the extreme tip of the tongue we really do not taste at all, but only feel. The nerves of pain and touch found here are exceedingly delicate and acute. Pungent, acid, alkaline, astringent, and saline flavors are recognized by the

tip of the tongue. The flavor of such substances as mustard, pepper, cinnamon, etc., is due to the feeling which they excite, combined with the odor of aromatic oils which they contain, and which the olfactory nerves detect in the breath when exhaled through the nose. This explains why the so-called taste of mustard, pepper, cinnamon, and similar substances is so much like their corresponding odors.

The pungent flavor of pepper, mustard, and similar substances, as well as the burning taste of alcohol, must be regarded as Nature's warning voice, saying, "This article is not good."

Sweet and *bitter* are recognized by the central portion of the tongue. The back part of the tongue and the throat recognize that peculiar class of tastes which produce the sensation of disgust when strongly excited, as in partaking too freely of fats, oils, animal foods, and rich pastries. The nerves which preside over this department of the sense of taste are in close sympathy with the stomach. This fact explains the nausea which is often produced by too rich foods.

431. **Uses of the Sense of Taste.**—One important object of the sense of taste is to inform us whether substances taken into the mouth are wholesome or poisonous. As a general rule, substances which have an agreeable flavor are good for food. This is at least true of natural productions. The poisonous parts of noxious plants have disagreeable and repulsive flavors, as do the poisonous parts of some edible plants—for example, the seed-balls of the potato-plant.

Another very important use of flavors is to excite the activity of the glands which secrete the digestive fluids, and to produce a relish for food. Substances which have

no flavor are insipid, and are rejected as food by most lower animals, as well as by man. Such substances, although wholesome, are often digested less readily than those which have decided flavors.

432. **Hygiene of the Sense of Taste.**—Condiments and all substances which produce a smarting sensation when applied to the tongue injure the nerves of taste, and destroy their ability to recognize delicate flavors, besides, as has been pointed out elsewhere, doing harm in various ways to the nervous system and the digestive organs. This class of substances is rejected by an unperverted taste.

433. **Alcohol and Tobacco.**—Strong liquors paralyze the nerves of taste. A teaspoonful of alcohol held in the mouth for a few minutes will so benumb the nerves that ordinary flavors cannot be perceived. The habitual use of strong liquors permanently injures this delicate and valuable sense.

The use of tobacco has practically the same effect upon the sense of taste. A man who chews or smokes tobacco cannot distinguish delicate flavors. On this account tea-tasters are obliged to abstain from the use of the weed. Is it not an outrage against our bodies to destroy the delicate sensibilities with which we are endowed, and in so doing deprive ourselves of the protection which these vigilant sentinels afford, at the same time inflicting upon other delicate organs of the body injuries which obedience to the dictates of our natural instincts would prevent?

It is a mistake to suppose that by the use of tobacco, alcohol, or any other narcotic or stimulant one really adds to the enjoyments of which the body is capable. When first used these drugs afford a certain pleasure of a low

type; but after one becomes accustomed to their use they no longer excite pleasure, but are used rather to relieve discomfort or actual pain than to produce pleasurable sensations. The particular drug habitually used becomes necessary to make the user comfortable without giving him pleasure. Thousands of those who use narcotic and intoxicating drugs, such as alcohol, opium, and tobacco, would gladly rid themselves of the bondage of a habit contracted in youth when ignorant of its evil effects.

The popular idea that tobacco is a cleansing agent, that it disinfects the mouth, and thus in some way contributes to the health of the user, is in the highest degree erroneous. The benumbing influence of this drug upon the nerves of taste is a good illustration of the poisonous influence which is exerted upon all living cells and upon every tissue and structure of the body. It not only injures the nerves of taste, but all other senses with which it comes in contact in the mouth, and extends its baneful influence to the whole body as well.

SUMMARY.

1. The nerves of taste are located in the tongue and pharynx.
2. Substances must be soluble in order to be tasted.
3. Most so-called tastes are combinations of the sense of taste with those of touch and smell.
4. The object of the sense of taste is to inform us whether articles taken into the mouth are unwholesome or poisonous.
5. Substances which have an unpleasant or pungent taste are usually harmful.
6. Condiments injure the sense of taste as well as the digestive organs, and are rejected by a healthy taste.
7. Alcohol and tobacco greatly impair the sense of taste.

CHAPTER XXXIV.

THE SENSE OF HEARING.

434. **The Simplest Ear.**—The organ of hearing is the ear. We can best understand the structure of this remarkable organ by first studying the ear in its simplest form. Such an ear is found in the barnacle, a small creature often found adhering to ships' bottoms, and to piers and other objects immersed in sea-water. Near the mouth of this little animal is found a small opening leading into a cavity running upward. From the top of this chamber hangs a minute sac filled with fluid, on the walls of which are spread out many delicate nerve fibres. This is the barnacle's ear. The ear of a lobster is much like it, only the little sac is lined with cells having delicate hairs which extend into the fluid, among which are numerous little grains called ear-stones.

435. **The Ear of a Fish.**—In a fish the little sac has connected with it three membranous canals, each like a half-circle in form, whence they are called *semicircular canals*. Each canal communicates with the sac by both its ends. From this fact the sac is termed the *vestibule*, or common hall. Both the vestibule and the semicircular canals are filled with fluid and lined with cells, some of which are hairy. The vestibule contains two or three ear-stones, which in some large fishes are an inch in length. The vestibule and semicircular canals are together called the *labyrinth*. The whole labyrinth is

enclosed in a cavity in the skull of the fish, and is attached to one side of it. From an external examination a fish appears to have no ears, as its ears have no external opening.

In a snake the bony cavity enclosing the labyrinth is connected with the skin by a little bone. In the turtle this little bone is enclosed in a second cavity in the skull, the outer end of which is closed by a membrane, thus forming a sort of *ear-drum*, the head of which is connected by the bone with the labyrinth in the inner cavity. The *drum-head* of the turtle's ear lies just under the skin.

436. **The Human Ear.**—The ear of man is essentially like that of these lower animals, only more perfect. It has, in addition, an external part composed of skin and cartilage, which aids in the concentration of sounds. It also has an addition to the labyrinth—a shell-shaped cavity called the cochlea, from its resemblance to a snail-shell. The cochlea contains a great number of nerve fibres of different lengths. In the human ear, also, the little bone found in the drum cavity is divided into three separate bones, the *incus* (anvil), the *malleus* (mallet), and the *stapes* (stirrup). The labyrinth contains minute ear-stones similar to those of the barnacle.

It thus appears that the perfect ear consists of three portions: the large outer portion, or *external ear*, a *drum cavity*, or *middle ear*, and the *labyrinth*, or *internal ear*.

Connected with the bones of the middle ear, in man, are two very minute muscles. The drum cavity is connected with the back of the throat by a small tube, the Eustachian canal.

From this comparative study of the structure of the ear, it is apparent that the most essential part of this

remarkable organ is the labyrinth, or internal ear, in which the nerve of hearing is distributed. This structure is found in some form, in all animals that can hear, from man down to the humble barnacle. The other portions of the ear are added in man and the higher animals, to render the hearing more perfect.

Fig. 45.—SECTION OF THE EAR.
1. External Canal; 2. Drum-head; 3. Ear Bones; 4. Labyrinth; 5. Eustachian Canal.

437. **How We Hear.**—Rest one end of a board upon a table, holding it in position by the left hand. Now, with the right hand, draw a pin across the board. It will be noticed that the board vibrates or trembles. Now press the side of the head against the upper end of the board and draw the pin across it again. A loud sound will be heard. This is because the vibrations or tremblings of the board have been communicated through the bones of the head to the internal ear, causing the fluid in the labyrinth to vibrate—which, in turn, causes vibration of the delicate hairs which hang out from the cells. By this means an impression is made upon the nerves of hearing, which, when conveyed to the brain, is recognized as sound. It is in this manner that the fish is able to hear with no external ear, sounds being conveyed to its ears through the bones of its skull.

We are able to hear the scratching of the pin, although

less distinctly, even if we do not place the ear against the board. In this case the vibrations of the board cause vibrations of the air, or sound waves, which are brought to the external ear, gathered by it, and transmitted by the drum-head and the little ear-bones to the fluid in the labyrinth, and thus to the nerves of hearing. All sounds are produced by vibrations of some sort.

The lowest musical note is produced by about sixteen and one-half vibrations per second, the highest by about fifty thousand vibrations. In some persons the musical part of the ear seems to be defective, while in others it has by cultivation been made so acute as to enable them to distinguish between notes having a difference of but one hundredth part of a tone.

The sense of equilibrium is supposed to reside in the semicircular canals. It has been found that if a certain part of the canal is injured in some lower animals, the creature will roll over and over constantly. Injury to another part will cause the animal to turn somersaults.

The object of the Eustachian tube is to allow a change of the air in the drum cavity, so as to keep it of about the same density as the air outside the body.

The air in the ear may be changed by a simple method which may sometimes be usefully employed. Grasp the nostrils between the thumb and finger so as to close the nose tightly. Take a full breath, and, closing the mouth, attempt to blow through the nose. The air, not being able to pass through the usual channel, is by the pressure forced up through the Eustachian canal to the middle ear. It does not pass through the ear unless the drum membranes have been ruptured by inflammation, a frequent result of scarlet-fever. If the membrane is perforated a whistling sound is often heard when the ears are inflated.

The inflation of the ears should not be repeated very frequently. If employed when the ears are "stuffed up" by a cold causing obstruction of the ear-tubes, it will frequently give relief and restore the hearing. Persons who work in diving-bells find it necessary to change the air in the ears, in order to prevent rupture of the membrane from the pressure of the atmosphere whenever the diving-bell is raised or lowered.

The little muscles of the middle ear tighten and relax the drum-head, for the purpose of adjusting it to receive loud and soft, high and low sounds.

The cochlea of the internal ear is supposed to contain that part of the nerve of hearing by which we distinguish musical sounds.

The canal of the external ear is studded with fine hairs, and lubricated by a viscid and very bitter substance, commonly known as *ear-wax*. The object of both hairs and wax is to prevent the entrance of insects into the canal.

438. **How to Care for the Ears.**—Observe the following rules respecting the care of the ears:

1. Never clean the ears with a pick or an ear-spoon. In health, the ear-wax dries up and falls out of itself. If ear-wax accumulates, the ears should be examined by an ear specialist.

2. Never allow cold water to enter the ears, and do not let the cold wind blow into them. If cotton is placed in the ear, do not neglect to remove it as soon as it is not needed.

3. To remove a foreign body, syringe the ear with warm water, leaning the head to one side, so that the object may drop out if loosened, and draw the ear upward and backward, to straighten the canal. If an

insect gets into the ear, pour in a little oil, which will suffocate it, when it may be removed by syringing.

4. Shouting into the ear may cause deafness. When a loud sound is expected, prepare for it by closing the mouth and covering the ears.

5. Never box or pull the ears. Permanent deafness may result.

6. A discharge from the ear may become dangerous to life. A physician should be consulted at once.

7. Avoid the use of "catarrh" nostrums and ear medicines.

8. A cold which causes partial loss of hearing should receive prompt attention. The foundation of incurable deafness is often caused in this way. Blowing the nose with great violence may result in injury to the ears.

439. **Tobacco and Ear Disease.**—The use of tobacco in any form often occasions deafness by causing disease of the throat or the nose, which leads to ear disease. The same may be said of the use of alcoholic liquors. Smoking, and especially the use of cigarettes, is exceedingly injurious to the ears, as is also that very unclean practice, the use of snuff.

SUMMARY.

1. The simplest ear is a little sac filled with fluid, on the walls of which are distributed the nerves of hearing.

2. A perfect ear is composed of three parts: the *external ear*, the *middle ear*, or *drum cavity*, and the *internal ear*, or *labyrinth*.

3. The internal ear is the essential organ of hearing.

4. We ordinarily hear through vibrations of the air, called sound-waves.

5. These waves cause vibration of parts of the middle ear, which communicate the impression to the nerves of hearing.

6. The Eustachian tube, which connects the middle ear with the throat, provides for a change of the air in the drum cavity.

CHAPTER XXXV.

THE EYE, AND HOW WE SEE.

440. **The Simplest Eyes.**—A polyp is able to see without eyes, or at least to recognize light, for it folds its arms when a cloud passes over the sun. A starfish sees by means of a little red spot containing nerve endings at the apex of each of its arms. A leech has a semicircular row of eight or ten eye-spots just above its mouth, which are much more satisfactory eyes. Each consists of a little spot of transparent skin, back of which is a layer of dark pigment, between the two being spread out the ends of the fibres of a nerve of sight. The eye of a leech contains all the essential parts of an organ of sight, but its vision is very imperfect.

Fig. 46.—The Eye.
1. Iris; 2. Pupil.

In the higher animals and man the colored layer and the nerves of sight are spread out on the inside of a rounded cavity in the skull, the front side of which is closed by a transparent membrane. The centre of the cavity is filled with transparent substances, through

which the light passes. This is a general idea of the eye, but we must study it more minutely.

In man the most important organs of sight are comprised within the eyeball, which is nearly round, and is placed in a socket in the skull. It consists of the following parts:

441. **Three Coats.**—The eyeball presents three membranous layers or coats: 1. The outer coat, consisting of a dense white membrane, the white of the eye, or the *sclerotic*, which covers the entire eyeball, with the exception of the transparent portion in front, the *cornea*. 2. The second coat, a colored layer, called the *choroid*, which lies in close contact with the outer coat at all places except just behind the cornea, where the *iris*, a movable muscular curtain lined with dark pigment, is substituted for it. The iris has an opening through its centre, the *pupil*. 3. The third, or *nervous coat*, called the *retina*, is spread out over the choroid, and lines the back part of the eyeball.

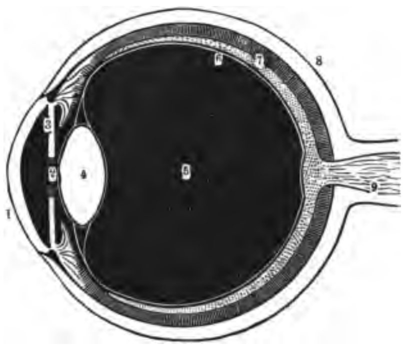

Fig. 47.—SECTION OF THE EYE-BALL.

1. Cornea; 2. Pupil; 3. Iris; 4. Crystalline Lens; 5. Vitreous Humor; 6. Retina; 7. Choroid; 8. Sclerotic; 9. Optic Nerve.

442. **The Retina.**—The retina contains the nerves of sight. It is formed by the spreading out of the end of the optic nerve, which enters the eyeball at the back side, nearly opposite the pupil. The retina is composed

of several layers of different kinds of cells, which are connected with the ends of the fibres of the optic nerve. The layer of cells next the choroid has a purple color. The color fades when the retina is exposed to light, but is constantly reproduced by the choroid. By means of the optic nerve, the retina is connected with the nerve centres of the brain which preside over the sense of sight.

443. **The Three Humors.**—The greater portion of the cavity of the eyeball is filled by a transparent jelly-like substance, called the *vitreous humor* (1). The front part of the vitreous humor is hollowed out to receive a much harder, transparent body, shaped like a lens, and called the *crystalline lens* (2). The lens is enclosed in a sheath, or capsule, which is also transparent. Its border is surrounded by a muscular ring. The lens is placed just behind the iris. The space between it and the cornea is filled with the *aqueous humor* (3), a watery fluid which runs out when the eyeball is punctured by any sharp instrument.

444. **The Eye-socket.**—The eye is placed, for safety, in a deep socket hollowed out in the skull, open in front, and communicating, at its back part, with the cavity of the skull by an opening through which pass the various nerves which connect the several parts of the eye with the brain. Lining the socket, and outside of the eyeball, is a quantity of fat, which acts as a cushion to protect the organ from the effect of jars.

445. **The Eyelids.**—The eyelids are folds of skin which protect the front part of the eyeball. They are lined with a delicate mucous membrane, which extends over the front portion of the eyeball. Along the edge of each eyelid may be seen the openings of numerous little glands, which pour out upon the edge of the eyelids an

oily substance, which prevents the overflow of the tears. The edge of the lids is also furnished with a row of hairs, the eyelashes, the use of which is to keep dust out of the eyes, and, if the lids are partially closed, to protect the eyes from too bright a light.

446. **The Tear-gland and Ducts.**—Within the socket of the eye, and at its outer and upper side, is placed a little gland which produces the tears. This secretion is constantly formed in small quantity for the purpose of moistening the eye. The secretion is drained away by means of two little canals, one opening at the edge of each lid, near the inner corner of the eye. The two canals open into a small sac at the nasal angle of the eye, from which the tears are carried into the nose by a duct called the *nasal duct.* When formed in too great quantity to be carried off by the natural channels, tears flow out over the lids and run down the cheeks, as in weeping.

447. **Muscles of the Eye.**—The eye is provided with six little muscles placed within the socket, by means of which it may be turned in various directions.

448. **How We See.**—Sight may justly be regarded as the most remarkable of all the senses. By means of it, through the aid of light, we are able to recognize objects at a distance, and, by the aid of suitable instruments, even at immense distances.

449. **Light.**—Light, like sound, is supposed to be produced by vibrations, which, emanating from luminous bodies and entering the eye, excite the sensitive retina. From the retina the optic nerve transmits the impression to the sight-centres in the brain, thus giving us the impression of light.

450. **Pictures Made by Lênses.**—If we hold a con-

vex lens before a window, and at a proper distance from a screen of thin oiled paper or ground glass, we may see upon the screen a perfect picture of the window, but much smaller than the original. Lenses may be so arranged as to make the pictures of objects larger or smaller, or of the same size as the original.

By noticing carefully the image made by a lens, it will be found that the picture formed by it is inverted, or wrong side up. This is because the rays of light cross each other in passing through the lens. It will also be observed that when a thin lens is used the image formed is farther away from the lens than when a thick one is used. The thicker the lens in proportion to its diameter, the nearer to it will be the image formed.

451. **Chemical Action of Light.**—Every one is familiar with the fact that a white garment which has become yellow, or a piece of unbleached muslin, may be made white by exposure to the sun. Many colored fabrics lose their color or fade when long exposed to the sun's rays. When the retina of the eye of an animal is exposed to the sun its purple color is bleached out in the same way. If, however, it is left in contact with its natural background, the choroid, and is placed in the dark, it soon recovers its color, so that the experiment may be repeated several times.

452. **Eye Pictures.**—If we allow the image formed by a lens to fall upon a retina which has been taken from the eye of an animal, the picture will remain upon the retina, being bleached upon it by the action of the sun's rays. This is exactly what happens when we see an object. The lens of the eye, assisted by the cornea, forms upon the retina an image which is bleached out in

the way described. By means of the optic nerve the impression made upon the retina is transmitted to the brain.

453. **Accommodation.**—If we hold a lens at a proper distance in front of a screen, we observe that the images of near and distant objects are not equally perfect. In order to get good images, we must either change the position of the lens, or use a thinner lens for distant objects and a thicker one for near objects. The lens of the eye is fixed at a definite distance from the retina, the screen on which the image is to be formed; and as it cannot be exchanged for a thicker or a thinner lens when we look at objects at different distances, nature has provided the eye with a delicate means by which the lens may be made thicker or thinner, and thus adjusted to see objects perfectly at different distances. This is the purpose of the circular muscle which surrounds the lens. The change in the eye in making this adjustment is termed *accommodation.*

Accommodation is exercised only for near objects, as the eye is so constructed that it sees without effort objects at a distance. A perfectly natural eye cannot adjust itself to see clearly objects which are nearer than five to eight inches. (See Experiments 22, 23, pages 276, 277.)

454. **Short-sight.**—Let us make an experiment. Take a lens which will make a distinct image of distant objects on a screen held a few inches behind it. Now move the screen a little farther from the lens. The image is now indistinct, but if we hold an object near the front of the lens a clear image of it will be formed upon the screen. It is evident, then, that if an eye should happen to have its retina farther from the lens than it should be, it would not be able to see very distant objects clearly, although near objects might be seen as

distinctly as by an ordinary eye and nearer to the eye. Some eyes are thus constructed, the globe of the eye being longer than usual, so that the retina is farther from the lens. Such an eye is said to be *short-sighted.*

455. **Long-sight.**—In other cases the eyeball is too short, bringing the retina too near the lens, so that near objects are not well seen, though distant objects are seen clearly. Such an eye is said to be *long-sighted.*

456. **Old-sight.**—At the age of forty-five the lens begins to become harder, so that it cannot be so accurately adjusted to near objects, and the individual finds it necessary, in reading, to hold the book or paper farther away from the eyes. This difficulty should be at once remedied by convex glasses, which must be changed for stronger ones as the person becomes older.

An old person who finds himself obliged to pull his glasses down upon his nose in order to see near objects well needs to obtain a stronger pair of glasses.

457. **Why We See Objects Upright.** — Although the image formed on the retina is inverted, the brain traces the rays of light back to the original, and so recognizes the object as erect.

458. **Why We See Single.**—Although we have two eyes, in each of which an image is formed, we ordinarily see objects single. This is because the eyeballs are kept by their muscles in such positions in reference to each other that the image is formed on the same portion of the retina of each eye. Sometimes the muscles of the eye do not act properly, so the two eyes are not focused alike, and then *double vision* occurs. (See Experiment 24, page 277.)

The advantage of two eyes in enabling us to judge of the form of objects, their distance, etc., may be readily

seen by attempting to thread a needle with one eye closed.

The lens and cornea of the eye are not so regular as perfect lenses, and hence do not form absolutely perfect images upon the retina. When this irregularity is very great, the images are so distorted that objects are seen very indistinctly. This defect is called *astigmatism*. It is a frequent cause of headache.

459. **Use of the Iris.**—The iris acts as a curtain to protect the eye from too intense light, contracting in a strong light and dilating when the light is dim.

460. **Color.**—The different colors of objects are due to the fact that white light is compound, being composed, according to the most recent authorities, of red, green, and violet rays. The retina is supposed to possess three distinct nerve elements, corresponding to these three primary colors. Rays which excite the green element we call green; so with red and violet. Rays which excite two kinds of elements produce compound colors, as orange, yellow, etc. Those which excite all equally give the impression of white light. (See Experiment 25, page 277.)

461. **Color-blindness.**—A person may be born with one or more of the color elements of his retina lacking or deficient. Such a person is said to be color-blind. The red element is most often lacking, so that the individual cannot tell red from green.

462. **Figures in the Eye.**—On looking steadily at a clear blue sky for some time, numerous bright spots may be seen moving to and fro. These are caused by the blood-corpuscles passing along the capillaries of the retina. "Long-sighted" persons, who are inclined to rub the eyes frequently, are often much troubled with dark spots before the eyes. These are particles of

pigment, or cells which have been detached by rubbing. Frequent rubbing of the eye should be avoided.

463. **How to Preserve the Eyesight.**—1. The effort to accommodate the eye in looking at near objects requires the action of several muscles, which must continue to act so long as the sight remains fixed upon near objects. When the effort is long sustained, these muscles become weary, and may become seriously diseased; hence the eyes should have frequent rest.

2. If the eyes become easily tired, and can be used but a short time without a *blurring of vision*, or aching of the eyeballs, it is probable that there is some serious defect, and a competent eye specialist, but not a travelling spectacle vender, should be consulted.

3. Never try to read or do work requiring close application of the eyesight with insufficient light. In reading, have the light come over the shoulder—the left, if convenient—and avoid using the eyes in a glaring light.

4. Avoid exposing the eyes to a sudden bright light. When the eyes are opened after being closed for some hours, as on awaking from sleep, some little time elapses before they are fully accustomed to the light. On this account it is not well to employ the eyes in reading immediately on waking in the morning.

5. Reading on the cars is injurious to the eyes, on account of the shaking which continually changes the distance between the book and the eye, and thus taxes most severely the organs of accommodation. Reading when lying down is also injurious, and for a similar reason.

6. The common use of the numerous domestic and patented eye-washes is a frequent cause of serious disease of the eye. When the eyes are simply irritated by excessive work, a cold, exposure to dust, or any similar

cause of irritation, frequent bathing with cool, tepid, or hot water; or rest, with a thin cloth wet in tepid water laid over the eyes, is a good and harmless remedy. If the case is not speedily relieved by some simple remedy of this sort, consult a competent physician.

7. If *lime* or any other *alkali* has gotten into the eyes, bathe them with water at once, and as quickly as possible apply a weak solution of vinegar, using about a table-spoonful in half a glass of water. If vinegar is not at hand, put a little oil into the eye and bathe with water.

464. **Dirt in the Eye.**—If visible, the foreign body may usually be removed by a corner of a folded handkerchief, or by the end of the finger previously moistened with oil. If out of sight, under the lids, a loop of hair passed under the lid and withdrawn will generally bring it out. A piece of steel or other sharp substance which has become imbedded in the eyeball should never be left to "work out," but a surgeon should be consulted at once.

465. **Inflammation of the Eyes,** if attended by pain and intolerance of light, demands the attention of a skilful physician at once. All inflammations of the eye attended by a mattery discharge are contagious by contact, and persons suffering in this way should never use the same handkerchief, wash-basin, or towel used by others, and should sleep alone. In consequence of neglect of this rule a dangerous disease of the eye sometimes extends to a large number of persons. Such a case requires careful medical attention.

466. **Relation of Sight to other Senses.**—By the information derived through the other senses the knowledge which we receive through the eye is rendered much more useful than it would otherwise be; for example, we should have no idea of solidity without the

sense of touch. Our ideas of distance would be imperfect if we were obliged to depend upon the eye alone.

467. **Alcohol and Tobacco.**—Grave diseases of the eye are constantly traced to the use of one or both of these poisons. Tobacco-blindness is a very common malady. The first symptom is color-blindness, which is followed by haziness of vision, and finally partial or complete loss of sight. Several diseases of the eye are due to the use of alcoholic drinks.

SUMMARY.

1. The simplest eye is a layer of dark pigment covered by transparent skin, the nerves of sight spread out between the two.
2. In man the eye consists of the *eyeball*, the *optic nerve*, the *eyelids*, and the *tear-gland* and *ducts*.
3. The eyeball has three investing coats—sclerotic-cornea, choroid-iris, retina—which enclose three transparent humors, *aqueous humor*, *crystalline lens*, *vitreous humor*.
4. The eyeball is moved by means of six small muscles.
5. By means of lenses we may produce pictures of objects.
6. The retina of the eye has a peculiar coloring-matter, which is bleached by exposure to light.
7. In seeing an object, a picture is bleached upon the retina by the action of the rays of light.
8. The eye accommodates itself to different distances by changing the form of the crystalline lens.
9. A healthy eye can adjust itself so as to see objects clearly between a point eight inches from the eye and the limit of distant vision.
10. "Short-sight," "long-sight," and "old-sight" are defects in accommodation which require the attention of an oculist.
11. We see objects single when the eyeballs are focused alike.
12. The iris regulates the amount of light received in the eye.
13. The retina has distinct elements corresponding to the three primary colors—red green, violet. Color-blindness is due to deficiency of the corresponding element.
14. Avoid overtaxing the eyes.
15. Tobacco-blindness is a common malady. The use of strong liquors also leads to disease of the eyes.

EXPERIMENTS.

Experiment 1.—Make a thin paste of starch or flour. Stir a teaspoonful of the paste in half a glass of water. When well mixed, add a drop of tincture of iodine, which may be obtained of any druggist. The solution will immediately change to a beautiful deep blue color. This is the chemical test for starch. A drop of iodine applied to a slice of bread will produce a dark blue spot.

Experiment 2.—Scrape the cut surface of a potato, and place a little of the milky juice thus obtained upon a slip of glass under a microscope. Multitudes of starch granules will be seen floating about or adhering to the surface of the glass.

Experiment 3. — Put in a flask or a bottle a half-pint of water as hot as the hand will bear without burning. Add a table-spoonful of sugar or molasses, and a half-teaspoonful of yeast. Shake well. Place where the temperature will remain at about blood-heat, or a little less. After two or three hours numerous bubbles will be seen in the liquid. If now it is submitted to the test described in Experiment 26, it will be found that alcohol is present, showing that alcohol is formed by fermentation.

Experiment 4.—Place in a small flask, such as is shown in the accompanying cut (Fig. 48), two or three ounces of beer, wine, cider, or any other alcoholic drink or mixture; "temperance bitters" answers the purpose admirably. Close the mouth of the flask with a cork perforated by a small glass tube or the stem of a clay pipe. Gently heat the flask over a flame, applying to the end of the tube from time to time a lighted match. When the liquid has reached the right temperature, and the air

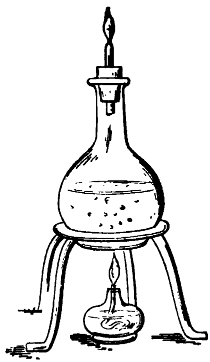

Fig. 48.—Test for Alcohol.

has been expelled from the flask, the blue flame of burning alcohol will appear at the outer end of the tube, showing that the liquid in the flask contains alcohol.

If a flask cannot be readily obtained, a bottle may be used instead, heating it in a basin of water placed on a stove. This experiment also illustrates the distillation of alcohol, the alcohol being burned as rapidly as it escapes from the bottle, instead of being condensed in a cool vessel.

Experiment 5.—Place a piece of lean, tender steak in alcohol or any strong liquor as whiskey or brandy. In a few days it will become almost as tough and hard as sole-leather.

Experiment 6.—Place in a goblet the white of an egg. Add two or three table-spoonfuls of strong alcohol. In a short time the clear albumen will become opaque, and soon after it will become as hard as though it had been dropped into boiling water. Strong alcohol affects all living tissues in the same way.

Experiment 7.—A few teaspoonfuls of alcohol were placed in a glass containing half a pint of water. Into this diluted alcohol a small minnow was dropped. The minnow immediately showed signs of distress. In five seconds it turned over on its back. In five seconds more it floated to the top of the water, and in one minute it ceased to give any sign of life.

Experiment 8.—Soak some iron-filings or bits of iron in vinegar for a few days. Add a spoonful of the vinegar, which will have dissolved a little of the iron, to a cup of tea. The black color which at once appears is evidence of the presence of tannin in the tea, which combines with the iron, forming ink.

Experiment 9.—Procure a specimen of blood by pricking the finger. A very small drop is sufficient. After transferring to a slip of glass, which should first be moistened by the breath,

immediately cover with a piece of very thin glass, such as is used for the purpose by microscopists, also taking the precaution to breathe upon the covering glass before applying it. This will spread out the blood in so thin a layer that it no longer presents the deep red color which it had at first. The blood may now be examined with a microscope. The blood corpuscles of the frog are much larger than those of human beings, and hence are much more easily seen with a small microscope. It is not easy to see white corpuscles in human blood, but in the blood of the frog they may be readily distinguished. The effects of alcohol upon the blood corpuscles may be shown by touching a drop to the edge of the cover glass while under the microscope.

Experiment 10.—Count the pulse while lying down. Assume a sitting position, and count again. Stand erect, and again count. Now exercise vigorously for two or three minutes—running up and down stairs, or jumping up and down, swinging the arms vigorously. Immediately after the exercise, count the pulse once more. If the pulse is sixty while lying, it should be about sixty-five to sixty-eight when sitting, seventy to seventy-five when standing, and perhaps eighty to ninety for a few minutes after active exercise. If the pulse rate is increased by change of position or by exercise very much above these figures, it is an indication that the heart is weak. Persons who use alcohol and tobacco show weak hearts when submitted to this test.

Experiment 11.—An experiment which has often been made, and which it is quite unnecessary to repeat, beautifully illustrates this regulation of the local blood supply. Divide the nerve which controls the blood-vessels of the ear of a white rabbit. Immediately the skin, previously white, becomes red and congested. In consequence of constantly receiving an undue amount of blood, it grows faster than the other ear, and soon exceeds it in size. This explains the formation of the rum-blossom, since alcohol paralyzes the nerves which control the small blood-vessels.

Experiment 12.—A simple experiment will illustrate the action of the vessels of the skin. Draw the unsharpened end of a pencil along the skin of the arm. A white line will be produced. In a few seconds this will disappear, and a red line will take its place, and will remain for some time. The white line is due to contraction of the small blood-vessels, and the red line to the relaxation or partial paralysis which follows the spasmodic contraction. A similar result follows the application of cold upon the surface, as in handling snow. Alcohol relaxes the small blood-vessels of the entire body. It is in this way that it invites apoplexy of the brain and inflammation of the lungs, liver, and other organs.

Experiment 13.—1. Obtain a quart fruit-jar or a similar vessel. By means of a tube, one end of which is placed in the mouth and the other inside the jar and reaching to its bottom, breathe into the jar for a minute, taking care to draw none of the air from the jar back into the lungs. Keep the mouth of the jar covered by the hand or a bit of card-board. Now remove the tube and cover the jar. Attach a piece of candle to one end of a wire, and, after lighting the candle, let it down into the jar. The flame will be extinguished, showing that a candle will not burn in air that has been breathed. 2. The presence of carbonic acid gas in the breath may also be shown by the following experiment: Take two drinking-glasses. Fill one glass half full of pure water. In the other place an equal quantity of lime-water. By means of the tube make the breath bubble through the pure water for one minute. Now breathe through the lime-water in the same way. The milky appearance produced in the lime-water demonstrates the presence of carbonic acid gas in the breath.

Experiment 14.—Ascertain the number of cubic feet of air in a school-room. Count the number of scholars, and calculate the length of time the air will remain pure without being changed. Also calculate how many feet of pure air should be furnished each hour to supply the number of persons occupy-

ing the room. If the room is provided with ventilating openings, examine them, and see if the air is passing in the right direction. This may be done by holding a piece of thin paper or the moistened finger against each register. Estimate the rate at which the air is passing, and by calculation determine whether the amount is sufficient for the number of persons in the room. The air should travel at the rate of about five feet a second.

EXPERIMENT 15.—The following simple method of employing artificial respiration should be practised until well understood. Have a person lie down upon a bench or a raised platform with the face upward, and the head hanging over one end. The operator, standing above the person's head, should take hold of both arms below the elbows, and draw them steadily upward above the head, retaining them in position two or three seconds; then allow them to go back to position, and press the elbows firmly against the sides of the chest. Drawing the arms upward will cause the air to rush into the lungs, and returning them to position and pressing against the chest forces the air out of the lungs. By repeating this simple operation twelve to sixteen times a minute, actual breathing may be very perfectly imitated.

EXPERIMENT 16.—Cut two blocks of ice to the same form and weight. Cover one with flannel, the other with cotton cloth of the same thickness. Expose both to the sun, and after an hour or two weigh each piece of ice, and see which has lost the more. It will be found that the woollen cloth is much the better protector for the ice, and for the same reason it affords better protection for the body.

EXPERIMENT 17.—Cover the skin of the arm with a piece of rubber cloth, oiled silk, or oiled muslin. After an hour remove the covering. Notice that the skin is moist. The moisture is due to the accumulation of the insensible perspiration, which ought to have escaped into the air. This shows the importance of wearing porous clothing. The moisture which accumulates

in the clothing while wearing a rubber cloak rapidly evaporates upon laying the rubber garment aside, and thus causes a chill which frequently results in a severe cold.

EXPERIMENT 18.—Tie a cord tightly around the finger. In a few moments the finger becomes swollen and cold. The venous blood accumulates in it, and the warm, vitalizing blood is kept out. The tighter the cord, the more marked the effect produced. Constrictions of any sort about the limbs or other parts of the body produce the same result in greater or less degree, and so occasion injury.

EXPERIMENT 19.—Place in a weak solution of muriatic acid a long slender bone, as a sheep's rib or the leg-bone of a fowl. In a week or two it will be found that the bone has lost its rigidity, although its form is not changed, and it may be bent double, or even tied in a knot, if long enough, without breaking. This change is due to the absorption of the salts from the bone. If the bone is dried and weighed, it will be found that it has lost about two-thirds its weight, provided it has remained in the solution a sufficient length of time.

EXPERIMENT 20.—The effect of compression upon the muscles may be readily observed by fixing a large cord or a strap tightly around the middle of the forearm. It will be found impossible to use the fingers with any degree of facility. They can scarcely be moved, in fact. The lesson to be drawn from this experiment is obvious.

EXPERIMENT 21.—Standing or sitting quietly, count the pulse very carefully, noting the number of beats per minute. Now slowly sip a glass of cold water. After a few seconds, count the pulse again. It will be found that the heart beats more slowly. The act of swallowing "inhibits" the action of the heart.

EXPERIMENT 22.—Take a pair of compasses. Bring the points very near together, and, without looking at them, touch both at the same time to the end of the forefinger. If they are very close together, both will be felt as one point. On sep-

arating them a little, they will be distinguished as two points. Test various parts of the body, and notice the distance required for the points to be felt as two.

EXPERIMENT 23.—Standing before a window, and holding up a pencil about fifteen inches from the eye, fix the sight first upon some distant object and then upon the pencil. It will be observed that when the pencil is seen distinctly the distant object is not well seen, and when looking sharply at the object in the distance, the pencil is indistinct and appears double. This proves that the eye cannot be adjusted so as to see both near and distant objects equally well at the same time.

EXPERIMENT 24.—Place an open book before the eyes at the usual distance for reading. Now move the book towards the eyes, and observe the point at which the letters are no longer seen distinctly. This is called the "near point" of vision, and marks the limit of the accommodating power of the eye.

EXPERIMENT 25.—Hold a pencil before the eyes. Press with the finger upon the outer or inner side of the ball of one eye. Two pencils will be seen instead of one. The distance between the two objects varies with the pressure made.

EXPERIMENT 26.—Prepare a circular disk of card-board about three inches in diameter. Divide the surface of the disk into three equal parts by lines drawn from the centre to the circumference. Paint one section with vermilion red, another with emerald green, and the third with violet. Now make the disk revolve by attaching it to the handle of a top and spinning it. When revolving rapidly the three colors of the disk will coalesce, giving a white or grayish color. By covering a section or portions of sections of the disk all different colors may be produced. For example, if the violet is covered with white paper, the disk, when revolved, will present a bright yellow color, by the combination of the red and green rays. If the green is partly covered in addition to the violet, the result will be an orange. All the colors of the spectrum may be produced in this way.

Experiment 27.—An experiment with what are known as "after-images" confirms this view of the nature of light, and also enables us to select complementary colors. Place a vermilion-red wafer on a white or gray ground; after looking steadily at it in a good light for two or three minutes remove the wafer, and in its place will be seen, after a few seconds, a bluish-green spot of the same size as the wafer. An orange-colored wafer will be followed by a sky-blue spot, green by pink, and yellow by violet-blue. The color which follows the one looked at is said to be complementary to it, since it is produced by such rays as, combined with the color first seen, will make white light.

Experiment 28.—Look at some bright object, such as a window or a gas-flame, for a moment. Now close the eyes. The object will still be seen, and will remain for some minutes, although the eyes are closed. If this experiment is made by a person who is in a state of chronic nicotine poisoning, he will notice that pictures seen in this way remain a much longer time than they should. This is due to the paralyzing effect of tobacco. The coloring matter by which the picture bleached upon the retina is obliterated is not supplied with the natural promptness, because the cells which produce it, like those of the rest of the body, are suffering from the benumbing influence of nicotine.

QUESTIONS FOR REVIEW

Chapter I.—Physiology, Anatomy, and Hygiene.—Define physiology. Define anatomy. Of what does hygiene treat?

Chapter II.—Cells, Tissues, Organs.—Of what are all living things composed? How do animals and plants grow? Why are animals and plants said to be organized? What is the difference between organic and inorganic objects? Name the ultimate elements of which the body is composed. How are the tissues filled and repaired? What is the effect of alcoholic drinks, tobacco, and other narcotics upon the tissues and tissue-builders? Define health. What is disease?

Chapter III.—Nutrition.—What is one of the results of all vital work? Of what do the bodily wastes consist? Define excretion. What is assimilation? What is meant by the term *disassimilation?* What substances are needed for nutrition? What is needed to preserve the health, in addition to food, water, and air? Name some substances which most seriously disturb the processes of nutrition. How does alcohol disturb nutrition? How do tobacco and opium disturb the nutritive processes? Do you know of any animal besides man that uses tobacco? (*Ans.—The tobacco-worm.*)

Chapter IV.—Foods.—What is the use of foods? Define a poison. What sort of substances do men and other animals require for food? What is the difference between the food required by plants and that required by animals? From what source do men and animals really derive all their food supply? (*Ans.—From plants.*) Name the six food elements. Are condiments food? Of what use in the body are starch, sugar, and fats? What tissues are nourished by albumen? What tissues are nourished by the salts? Of what use are indigestible elements?

Chapter V.—Drinks.—What is the only substance that will quench thirst? Name some of the uses of water. What kinds of impurities are found in water? Which of these are most dangerous of all? From what sources are the germs found in water chiefly derived? Is ice likely to be impure, and when? What are the qualities of pure water? (*Ans.—Tasteless, colorless, odorless.*) May impurities of the water be

detected? How may impure water be purified? Is filtration alone a perfectly safe method of purifying water? Should water be used as a drink freely, or sparingly? Name some unwholesome drinks. Are these drinks proper substitutes for water?

CHAPTER VI.—The Organs of Digestion.—Define digestion. Do plants digest? Name the principal parts of the digestive apparatus. How many sets of teeth does each person have? How many teeth in each set? When do the permanent teeth begin to appear, and when is the set completed? What is the use of the salivary glands? How is the gastric juice produced? How many digestive principles does it contain? Name them. What is the intestinal juice? What digestive fluid is produced by the liver? What is the portal circulation? What fluid is produced by the pancreas? How many digestive principles are contained in the pancreatic juice?

CHAPTER VII.—The Digestive Fluids.—How many digestive fluids? Name them. How many digestible food elements? Name them. What does the saliva digest? What does the gastric juice digest? What does the bile digest? What does the pancreatic juice digest? Why is the pancreatic juice able to digest so many different food elements? What does the intestinal juice digest? How is starch digested? How is albumen digested? How are the fats digested? How is cane-sugar digested? How are the salts digested? How is starch changed in digestion? Into what is cane-sugar converted by digestion? Into what is the albumen changed? What change is produced in the fats by digestion? In what does the digestion of the salts consist?

CHAPTER VIII.—General View of the Digestive Process.—Name the five principal divisions of the digestive apparatus. Name the five food elements. Name the five digestible food elements. How many digestive processes? Name them. What other effect has the saliva upon the food besides the digestion of starch? What other action has the gastric juice besides the digestion of albumen? What other functions has the bile besides the digestion of fats? What are the lacteals, and what is their use? What is the portal vein? To what organ does it convey the blood?

CHAPTER IX.—The Hygiene of Digestion.—To what do the chief errors respecting diet relate? What are the principal errors relating to the manner of eating? What harm from drinking too freely at meals? What is the effect of iced foods or drinks upon digestion? Why is it injurious to eat between meals? Should one eat just before retiring at night? Why is this practice injurious? Mention errors relating to the quantity of food. Name those qualities and substances which render

food unwholesome. Why are pepper and other condiments injurious? Why is baking-powder harmful? What does vinegar sometimes contain? Mention good substitutes for vinegar. Why is fried food indigestible? Why should one avoid the use of pastry? What evil consequences arise from the use of food containing an excess of albuminous elements? What injury may result from the use of excessive quantities of fat? Of sugar? Why is candy injurious? What harm may result from the use of unripe fruit? What are the dangers of using decayed foods? Give some examples of decayed food. (*Ans.—Cheese, undrawn game, decaying fish and meat.*) Mention practices which are injurious to the teeth. How should the teeth be cared for to keep them in health?

Chapter X.—Alcoholic Drinks, Tobacco, and other Narcotics.—Are all narcotics poisonous? Mention the narcotics in most common use. (*Ans.—Alcohol, tobacco, opium, tea, and coffee.*). How is alcohol produced? What is the cause of fermentation? How is pure alcohol obtained? How much alcohol do the various alcoholic drinks contain? Is hard cider intoxicating? How long does cider remain sweet after being made? Name some other members of the alcohol family besides alcohol. Describe the chemical properties of alcohol. Is alcohol a poison to plants? Give proofs. Is alcohol a poison to animals? Give proofs. Is alcohol a poison to human beings? Give proofs. Describe the influence of alcohol upon the stomach. Describe Dr. Beaumont's experiments upon Alexis St. Martin. What is the influence of alcohol upon digestion? What did Dr. Roberts discover in relation to alcohol? What were the effects of four ounces of claret upon digestion? Of two ounces of brandy? What dreadful disease of the stomach is sometimes produced by alcohol? What organ next to the stomach is most exposed to injury from alcohol? What name is given to a liver damaged by alcohol? Is alcohol a food? What evidence have we that it is not a food? Does alcohol increase strength? Why does a person who has taken alcohol seem to be stronger? What other drugs besides alcohol possess the power to lessen tissue waste? Should arsenic or opium be considered a food on this account? What did Dr. Parkes show respecting the influence of alcohol upon muscular strength? What has been shown by Drs. Davis and Richardson respecting the effects of alcohol upon animal heat? What is the alcohol appetite? What is the effect of moderate drinking? What do life-insurance records show? What about bitters? Should alcohol be used in cookery? Do candies ever contain alcohol? What is absinthe? What was the origin of tobacco-using? What is the effect of tobacco upon the stomach?

Upon the throat? Upon the ear? What dreadful disease of the lips, tongue, or throat, is produced by tobacco? How do we know this disease is the result of tobacco-using? What narcotic poison is found in tea and coffee? What other injurious substances are contained in tea and coffee? What is the effect of tea and coffee drinking upon digestion? Are tea and coffee foods? Mention other narcotics which are habitually used. What is the poison-habit?

Chapter XI.—The Blood.—Why is the circulation of the blood essential to nutrition? Of what is the blood composed? What is the use of red corpuscles? Of white corpuscles? To what may the blood be compared? What remarkable property is possessed by the serum of the blood? How may the ability of the serum of the blood to destroy germs be lost?

Chapter XII.—The Heart, Blood-Vessels, and Lymphatics.—What are the chief means by which the blood is circulated? Describe the heart. Which of the cavities of the heart receive blood? Which send out blood? By what is the blood conveyed from the heart? What is the use of the veins? What are the capillaries? Describe the structure of the arteries; of the veins; of the capillaries. What structures are found in the veins which are not found in the arteries? Name the three circulatory systems. Where does the systemic circulation begin and end? Where does the pulmonary circulation begin and end? Through what part of the body does it circulate the blood, and for what purpose? From what organs does the portal vein gather blood? To what organ does it convey the blood, and for what purpose? Of what does the lymphatic system consist? What is the use of the lymph-vessels? Where do the lymph-vessels originate? Of what is the lymph composed? How does the lymph act as a medium of exchange between the blood and tissues? What name is given to the lymph-vessels connected with the intestines? To the lymph-glands similarly connected? What is the use of the lymph-glands?

Chapter XIII.—How the Blood is Circulated.—Of what does the circulatory system consist? What is its centre? To what may the heart be compared? How much work is done by the heart in twenty-four hours? How is the action of the heart regulated? What is the pulse? Where can the pulse be felt? Describe the capillary circulation. Describe the circulation in the arteries; in the veins. What is the difference between venous blood and arterial blood? How is the blood supply of an organ regulated? Does the heart ever rest?

Chapter XIV.—Hygiene of the Heart, Blood, and Blood-Vessels.—How may the strength of the heart be increased? What is the effect

of violent exercise upon the heart? What is the effect of heat and cold upon the heart? What is the effect of loss of sleep upon the blood? What is the effect of anger and other violent exercises upon the heart? What is the influence of poor food, condiments, etc., upon the blood? Describe the effect of alcohol upon the blood. How does alcohol cause fatty degeneration? What is the effect of alcohol upon the heart and blood-vessels? How does alcohol lessen animal heat? Describe Dr. Parkes's experiment in relation to the effect of alcohol upon the pulse. What effect does tobacco have upon the heart? What is the effect of tobacco upon the pulse? What effect do tea and coffee sometimes have upon the heart? What should be done for a person who has fainted? What should one do who has taken a severe cold?

CHAPTER XV.—The Organs of Respiration.—Name the principal parts of the respiratory apparatus. Name the different portions of the air-passages. Describe the lungs. About how many air-cells are contained in the lungs? What is the pleura? Describe the thorax. What is the diaphragm?

CHAPTER XVI.—How We Breathe.—What are the two acts of breathing called? To what may the chest be compared in its action? What causes the air to enter the chest in breathing? Where should the principal movement be in the act of breathing? How many breaths are taken per minute? Mention and describe the principal modifications of breathing. What is the capacity of the lungs? How much air is taken in at each breath in ordinary respiration? What is the composition of the air? Describe the properties of oxygen. Of what use is nitrogen? What are the properties of carbonic-acid gas? How may the presence of carbonic-acid gas be detected? How much oxygen is contained in each ordinary breath when taken in? How much of this is absorbed in the lungs? How much carbonic-acid gas is contained in each expired breath? What else does the breath derive from the blood while in the lungs besides carbonic-acid gas? What is the most poisonous substance found in the expired breath? What changes occur in the blood during respiration? What becomes of the oxygen carried to the tissues by the blood? Of what use is oxygen to the tissues? What is the relation of oxygen to animal heat? To what may the body be compared in relation to the production of heat? How much heat is given off by the body each twenty-four hours? In what part of the body is the production of heat most active? What tissue element is consumed in heat production? By what means may the accumulation of fat be regulated? Name the different processes connected with respiration.

CHAPTER XVII.—Hygiene of the Lungs, and Ventilation.—What substance is more than all others most essential to life? What is impure air? Name some of the most common impurities found in the air. Mention some of the sources of air impurities. What are germs? What is sewer gas? May we be exposed to danger from it? How does coal gas destroy life, and how may we be endangered by it? Of what is dust largely composed? How may we protect ourselves from the dangers of dust? What is disinfection? Name some of the most valuable natural disinfectants. Name the most valuable chemical disinfectants. How should sulphur be used in disinfecting a room? How much is required? Is the inhalation of sulphur fumes dangerous to life? For what purposes, and how, should chloride of lime be used as a disinfectant? What symptoms are produced by breath-poisoned air? What is the purpose of ventilation? How much air is spoiled each hour by a single person? How much pure air should be introduced for ventilation per hour for each person? How many openings are needed for ventilation? How large an opening is required for each person, the opening being covered by a register? Where should the fresh-air inlets be placed? How large should the foul-air outlet be for each person, and where should it be placed? Should the fresh air be admitted warm or cold? If fresh air is admitted cold, where should the outlet be placed? With what should foul-air outlets be connected to secure good ventilation? When should the ventilating shaft be heated? How large should the ventilating shaft be? Why should moisture be added to the air in the winter-time? Describe natural breathing. Do civilized men and women breathe alike? Why not? Do men and women of savage tribes breathe alike? Why? Under what circumstances do civilized men and women breathe alike? Describe some exercises which are good lung gymnastics. What daily practice is a good means of preventing colds? What injury results from mouth breathing? Describe artificial respiration. What precaution may be taken to avoid injury from hot gases? What should be done in case of choking? Describe the effect of alcohol upon the lungs. What is the effect of tobacco upon the respiratory organs?

CHAPTER XVIII.—The Voice and Speech.—Describe the larynx; the vocal cords. How is the voice produced? What is speech? By what means may the voice be preserved? What kinds of food injure the voice? How do alcohol and tobacco affect the voice?

CHAPTER XIX.—The Skin and Kidneys.—What are the principal parts of the skin? Describe the cuticle; the dermis. What kinds of glands does the skin contain? Describe them and their use. What is

the amount of perspiration daily produced? What are the uses of perspiration? Describe the hair. What is its use? Describe the nails and their use. Name the several uses of the skin. How soon will death occur if the skin is entirely obstructed, and why? Where are the kidneys located, and what is their size? Describe the structure of the kidney. What are the ureters? What is the purpose of the urinary secretion?

CHAPTER XX.—The Hygiene of the Skin and the Kidneys.—What are essential to the health of the skin? Are cosmetics injurious, and why? How may the complexion and the general health of the skin be best preserved? What dangers connected with the use of hair dyes? How may the scalp be kept in a state of health? How should the nails be cared for? What is the cause of ingrowing nail? What are corns and callus? How should an ordinary burn be treated? A severe one? What are the effects of alcohol and tobacco upon the skin? What is the effect of tea upon the skin? Name some of the principal causes of disease of the kidneys. How does alcohol injure the kidneys? What is the influence of tobacco upon the kidneys? What other drugs are likely to injure the kidneys?

CHAPTER XXI.—Bathing.—Why is frequent bathing necessary? What is the effect of water upon the skin? What is the effect of a cold bath upon the skin? A hot bath? What is the proper temperature of an ordinary bath? How often should a bath be taken? Describe a convenient method of taking a bath. Why is soap needed? Mention the most important rules relating to a bath.

CHAPTER XXII.—Clothing.—Name the most important materials for clothing in the order of their value. Why is wool preferable to linen? What objection to rubber or mackintosh garments? Why must clothing be adapted to the season and weather? How should the feet be clothed? How should the neck be clothed? Name some of the evils which result from tight lacing. How does tight lacing produce gall-stones? How often should the clothing be changed, and why? What clothing should be worn at night? How should a bed be cared for? What colors sometimes render clothing poisonous? How may injury from this source be obviated?

CHAPTER XXIII.—The Bones, Their Uses, and How to Care for Them.—Of what is the skeleton composed? What is the use of the skeleton? What is the strength of bony tissue as compared with oak? Name some of the different forms of bones in the skeleton. How does cartilage differ from bone? What is a joint? Describe the different structures which enter into a joint. Mention some of the

different kinds of joints. How many bones in the skeleton? How many of these are found in the head? In the trunk? In the upper extremities? In the lower extremities? Name the bones of the trunk. What structure is formed by the vertebræ? Name the bones of the arm. Name the bones of the leg. Describe the composition of bones. What is the difference between the bones of infancy and those of old age? Name the several uses of the bones.

CHAPTER XXIV.—Hygiene of the Bones.—What do the bones require for their proper development? Name a bone disease which is due to a lack of proper food. What is the influence of exercise upon the bones? What is the influence, upon the bones, of exercise at too early an age? What is the result of sitting in improper positions? Mention some common injury to the bones and joints. What should be done when a bone is broken or dislocated? What is a sprain? A bunion? What influence have alcohol and tobacco upon the bones? What is the effect of alcohol upon the blood-making cells found in the bones?

CHAPTER XXV.—Anatomy and Physiology of the Muscles.—Of what is a muscle chiefly composed? How many muscles are found in the body? Describe a tendon. Mention some of the different forms of muscles. Name and describe the two general classes of muscles. How does the heart differ from any other muscle in the body? Name the two most important uses of the muscles of the face. What are the principal uses of the muscles of the trunk? What is the most important muscle of respiration? Name the largest muscles of the arm. Name the principal movements of the arm. Name the largest muscle of the leg; the longest. How does a muscle contract? How does the action of the involuntary muscles differ from that of the voluntary muscles? How much work is daily done by the muscles of an ordinary laborer? How much more work is a horse able to do than a man? In what way do the muscles employ the bones in movements? To what is the chief value of the hand due? Describe the difference between the acts of running, walking, and leaping. Name some of the general uses of the muscles. How does the use of the muscles regulate nutrition? Of what special sense are the muscles the seat?

CHAPTER XXVI.—How to Keep the Muscles Healthy.—What is most essential to the health of the muscles? What is the effect of neglect to exercise the muscles? What is the effect of exercise upon the lungs? Upon the heart? Upon the circulation and all the tissues? Why should exercise be regular? What is the special value of gymnastic exercises? Does proper physical exercise tend to morality?

How may games become injurious? What is the effect of improper positions? What is the proper position in sitting? In standing? What is the effect of alcohol upon the muscles? What produces the chap-fallen countenance of a drunkard? What is the effect of alcohol upon the strength? Describe Dr. Parkes's experiment. How much was a young man's strength diminished by two ounces of brandy? What is the influence of tobacco upon development? How has this fact been recognized by the French and other governments? What is the influence of tea and coffee upon the strength?

CHAPTER XXVII.—The Brain and Nerves.—Why are the brains and nerves required? What are two elements of nerve tissue? What is a ganglion or nerve centre? Of what is a nerve trunk composed? What is the weight of the brain? What is the average weight of the brain in men? Describe the cerebrum. Describe the cerebellum. How many nerve cells is the brain supposed to contain? Describe the central ganglia. What and where is the optic thalamus? Describe the medulla oblongata. Describe the structure of the spinal cord. How many nerves are sent out from the skull? How many from the spinal cord? What constitutes the cerebro-spinal nervous system? Describe the sympathetic nervous system. In what portions of the body are the sympathetic nerves chiefly distributed?

CHAPTER XXVIII.—How We Feel and Think.—What is the difference between a nerve centre and a nerve? In what direction in relation to the brain do sensory nerve fibres convey impulses? In what direction do the motor fibres convey impulses? Mention some of the different kinds of sensory nerves, special and general. Mention the different kinds of motor nerves. What is the essential nature of the brain? How do nerves conduct? How long does it take to feel? What is reflex action? What is automatic action? Mention the most important uses of the spinal cord. What is the function of the medulla oblongata? Of the cerebellum? Of the cerebrum? Describe the effect of removal of the cerebrum in different animals. What portion of the brain is especially essential to enable one to learn a trade? What is inhibition, and of what use is this function? How is a habit formed? How do we remember?

CHAPTER XXIX.—Hygiene of the Brain and the Nerves.—Why is mental exercise necessary? Why is too much study harmful? Can the brain retain an indefinite amount? How many distinct facts can be remembered by the strongest brain? Why is it injurious to study when very weary? How may one remember well? What is the influence of mental worry? Of excitement? Why is sleep essential?

Why should we cultivate self-control? How may unwholesome food affect the brain? What is the effect of overeating? Why is muscular exercise essential for students? How much exercise should a student take daily?

CHAPTER XXX.—Effects of Alcohol upon the Brain and Nerves.—How does alcohol affect the brain? What is the significance of the whiskey flush? What is the condition of a person who is dead drunk? How does alcohol escape from the body? What is alcoholic nervousness? How does alcohol produce sleeplessness? What is delirium tremens? What is the effect of alcohol upon nerve centres and fibres? What is locomotor ataxia? Is alcohol a stimulant? What are the effects of alcohol upon character? What are the hereditary effects of alcohol? Why is moderate drinking dangerous? What are the effects of tobacco upon the mind? What is the effect of cigarettes? Are the effects of tobacco-using hereditary? What is the effect of opium upon the brain and nerves? Of chloral? Of tea and coffee? What is a poison-habit? How are poison-habits formed?

CHAPTER XXXI.—Special Senses: the Sense of Touch.—What is sensation? How many kinds of sensations? Mention sensations which relate to conditions within the body. Name those which relate to external objects. What are the latter called? How is pain produced? What is the use of pain? Where is the sense of touch located? In what parts of the body is it most acute? What is the sense of space, or locality? The sense of pressure? The sense of touch? The sense of temperature? Of what use is the sense of temperature? What is the muscular sense? Where is it located, and what is its use? What are the effects of alcohol upon the sense of touch and its modifications?

CHAPTER XXXII.—The Sense of Smell.—Where is the olfactory sense located? Of what use is the sense of smell? How may the sense of smell be abused? Why are strong odors objectionable? What are the effects of alcohol and tobacco upon the sense of smell?

CHAPTER XXXIII.—The Sense of Taste.—Where is the sense of taste located? How many nerves of taste? Is it necessary that a substance should possess flavor? Do we usually recognize flavors by the sense of taste alone? What impressions are recognized by the tip of the tongue? By what nerves is the sensation produced by such substances as mustard, pepper, etc., recognized? How are sweet and bitter substances recognized? What are the uses of the sense of taste? What is the effect of condiments upon the sense of taste? What is the influence of alcohol and tobacco upon this sense? Is alcohol useful to the mouth as a cleansing agent?

CHAPTER XXXIV.—The Sense of Hearing.—Of what does the simplest ear consist? Describe the ear of a barnacle; of a lobster; of a fish; of a snake; of a turtle. In what respects does the external ear of a man differ from the ear of a turtle? Describe the internal ear in man. In what respect does it differ from a snake's or a turtle's? In what respect does the middle ear differ? How do we hear? Describe an experiment which illustrates the means by which sounds are recognized by the ear. By what number of vibrations is the lowest musical note produced? The highest? What is the object of the Eustachian tube? What is the purpose of the ear-wax? Give some rules for the proper care of the ears. What is the influence of tobacco upon the ears?

CHAPTER XXXV.—The Eye, and How We See.—Of what does the simplest eye consist? Describe the eye of a starfish; of a leech. Name the principal parts of the human eye. Describe the sclerotic; the cornea; the choroid; the iris; the retina; the vitreous humor; the crystalline lens; the aqueous humor; the eye-socket; the eyelids; the tear-glands; the ducts; the muscles of the eye. In what respect does light resemble sound? How are impressions transmitted from the eye to the brain? Describe an experiment with lenses which illustrates the action of the eye. Describe the chemical action of light. What has this action to do with seeing? How does the eye adjust itself so as to see objects at different distances? What is short sight? Long sight? Old sight? Why do we see objects upright? Why do we see objects single? How is double vision produced? What is astigmatism? What is the use of the iris? What are the primary colors? How are we enabled to see different colors? Explain color blindness. What is the cause of figures in the eye? Give some rules for the preservation of the eyesight. What should be done if a caustic alkali has entered the eye? How may dirt be removed from the eye? What should be done in a case of inflammation of the eyes? How is sight assisted by the other senses? What is the effect of alcohol and tobacco upon the eyes?

GLOSSARY.

The following list of words is here presented chiefly for the purpose of indicating the pronunciation. Definitions are given only for words which are not fully explained in the text when first used:—

Ab do'men. The lower cavity of the trunk.
Ad'i pose tis sue. Fat.
Al bu'mi nous. Resembling albumen.
A mœ'ba.
Am y lop'sin.
An a tom'i cal.
An ti sep'tic. Preventive of decay or fermentation.
A or'ta.
A'que ous.
Ar sen'i cal.
Ar te'ri al.
A stig'ma tism.
Au'ri cle.
Au to mat'ic. Self-acting.
Ax il'la. Arm-pit.

Bron'chi al.
Bun'ion.

Cap'il la ry.
Ca'se in.
Cer e bel'lum.
Cer'e brum.
Chlo'ral.
Cho'roid.
Clav'i cle.
Co'ca ine.
Coc'cyx.
Con vo lu'tions.
Cor'ne a.
Cor'pus cle.
Crys'tal line.
Cur'pus stri a'tum.
Cu'ti cle.

Deg lu ti'tion.
De lir'i um tre'mens.
Di'a phragm.
Dis as sim i la'tion.

Ep i der'mis.
Ep i glot'tis.
Ep'i lep sy.
Ep i the'li um.
Eu sta'chi an.
Ex cre'tion. A substance thrown off from the body.

Fib'u la.

Gan'gli on.
Glu'cose.
Gly'co gen.
Gym nas'tics.

Hash'ish.
He pat'ic. Pertaining to the liver.
Hu'me rus.
Hy'oid.

In'cus.
In hi bi'tion.
In som'ni a. Sleeplessness.
In tes'ti nal.
I'ris.

Lab'y rinth.
Lac'te al.
Lar'ynx.
Lo co mo'tor a tax'i a. A disease in which the patient walks with a staggering gait.

Mal'le us.
Mas ti ca'tion.
Me dul'la ob lon ga'ta.
Mes en ter'ic.
Mi'tral.
Mus'cu lar.

Nar cot'ic. A stupefying drug.
Nic'o tine.
Ni'tro gen.

Œ soph'a gus.
Ol fac'to ry.
Op'tic thal'a mus.
Os'se ous.

Pan'cre as.
Pa pil'læ.
Pa tel'la.
Pec'to ral.
Per i car'di um.
Per i os'te um.
Per i stal'tic.
Per spi'ra to ry.
Phar yn ge'al.
Phar'ynx.
Phos phor es'cence. A light similar to that emitted by phosphorus as seen in the dark.
Plas'ma.
Pleu'ra.
Pneu'mo graph.
Pro na'tion.
Pty'a lin.
Pul'mo na ry.
Py lo'rus.

Ra'di us.
Rec'tus.
Ret'i na.

Sa'crum.
Sal'i va ry.
Sar to'ri us.
Scap'u la.
Scle rot'ic.
Se ba'ceous.
Se cre'tion. A substance formed from the blood by a gland.
Sen'so ry. Pertaining to sensation.
Skel'e ton.
Som nam'bu lism. Sleep walking.
Sphyg'mo graph.
Sta'pes.
Ste ap'sin.
Ster'num.
Su pi na'tion.
Syn on'y mous. Of like meaning.

Ten'do A chil'lis.
The o bro'mine.
Tho rac'ic. Pertaining to the thorax.
Tho'rax.
Tib'i a.
Tra'che a.
Tri'ceps.
Tri chi'na.
Tri cus'pid.
Tryp'sin.
Tyr o tox'i con.

Ul'na.

Ve'na ca'va.
Ven'tri cle.
Ver'te bra.
Ves'ti bule.
Vit're ous.